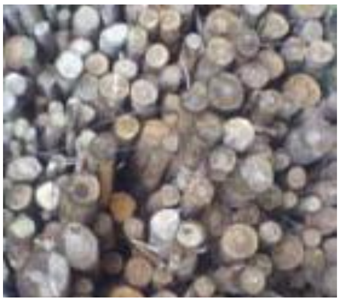
# The UK's Biomass Energy Development Path



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## Abstract

*Biomass energy forms an important part of the UK renewable energy portfolio in helping to achieve national carbon reductions. In 2007, it made up three per cent of the total UK energy supply and this figure is set to rise, with biomass energy due to make up just under a third of the 2020 UK renewable energy target. Biomass energy has several unique advantages over other renewable energy options: its widespread availability; relative independence from environmental fluctuations; employment intensity; and its flexibility in terms of energy carrier and diversity of supply options. Different biomass feedstocks can be harnessed via various different conversion technologies into all the major energy carriers (heat, liquid, gas and electricity) but this paper primarily focuses on electricity and heat generation – two of the most widely used forms of biomass energy in the UK.*

*The past decade has seen a growing interest in biomass energy in the UK, though there has been criticism that the development path has so far been rather fragmented, with disjointed government support and policies. Electricity generation has received significant support through policies such as the Renewables Obligation (RO), in which newer biomass energy technologies have been favoured. Some of the UK government departments involved in biomass energy have undergone restructuring over the last few years, to increase their overall effectiveness. There are a number of biomass power plants currently in operation, and almost seven gigawatts (GW) of medium and large-scale biomass power plants now in development.*

*Planning permission granted for the construction of so many biomass power plants, with the total estimated potential annual feedstock demand of 50-60 million tonnes, has raised public concerns. With this demand vastly exceeding the total annual UK biomass production, there are worries as to how feedstock will be developed in the UK to supply them all, or what the impacts of imported feedstock might be on livelihoods and ecosystem services elsewhere. There are growing efforts to build up different sources of biomass in the UK, such as from increased energy crop use and harvested wood fuel from currently under-managed woodlands. Waste biomass also has potential, since much of it would otherwise be sent to landfill.*

*The greenhouse gas (GHG) emission savings from biomass energy varies between the type of feedstock and technology used, as well as whether 'good' or 'bad' practice is adopted, but all are significantly better than fossil fuel equivalents. With many plants now relying on imported feedstock, however, there are also emissions associated with transport over long distances.*

*Barriers to biomass energy in the UK include a weak supply chain, a lack of public awareness and a long and confusing list of grants. There are many lessons that can be drawn from the UK for application in developing countries; such as the wide variety of employment opportunities offered through biomass energy, the importance of sufficient support for sustainable supply chain development, the need for good government coordination, and finally, the development of a coherent biomass strategy.*


**Cover pictures courtesy of Forth Energy**

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# Glossary

| | |
|---|---|
| CEN | European Committee for Standardisation |
| CHP | Combined Heat and Power |
| DECC | Department of Energy and Climate Change |
| DEFRA | Department for Environment, Food and Rural Affairs |
| DTI | Department of Trade and Industry |
| EEA | European Environment Agency |
| GHG | Greenhouse gas |
| HETAS | Heating Equipment Testing and Approval Scheme |
| NAPA | National Adaptation Programme of Action |
| NNFCC | National Non-food Crops Centre |
| ORED | Office of Renewable Energy Deployment |
| PRSP | Poverty reduction strategy paper |
| RDA | Regional Development Agency |
| RE | Renewable energy |
| REDD | Reduce Emissions from Deforestation and Forest Degradation |
| RET | Renewable energy technology |
| RHI | Renewables Heat Incentive |
| RO | Renewables Obligation |
| ROC | Renewables Obligation Certificate |
| SRC | Short rotation coppice |
| SRF | Short rotation forestry |
| WID | Waste Incineration Directive |

# 1 Introduction

With anthropogenic climate change now widely accepted, building a low carbon UK is becoming increasingly important (HM Government, 2009a). The last decade has seen a greater commitment to a greener economy, through policies such as the European Union Emissions Trading System and the Renewables Obligation (RO). As part of a growing commitment by the government to demonstrate their dedication to an improved energy sector, in July 2010 the UK government presented the first Annual Energy Statement, which reviews various aspects of energy policy including renewables; and alongside this, a 40 year energy action plan (Energy Efficiency News, 2010). Leading by example, Britain was the first country worldwide to make carbon reductions legally binding through the 2008 Climate Change Act which set emissions cuts at 34 per cent by 2020 and no less than 80 per cent by 2050. Renewable energy deployment will be one focus in helping to achieve this, with a legally binding target to obtain 15 per cent of overall energy requirements (electricity, heat and transport) from renewables by 2020 (HM Government, 2009a).

Currently 75 per cent of the UK's electricity comes from coal and gas, but the UK government (2009a) claim that by 2020, electricity generated from renewable energy could multiply five times from six per cent to just over thirty per cent (Figure 1).

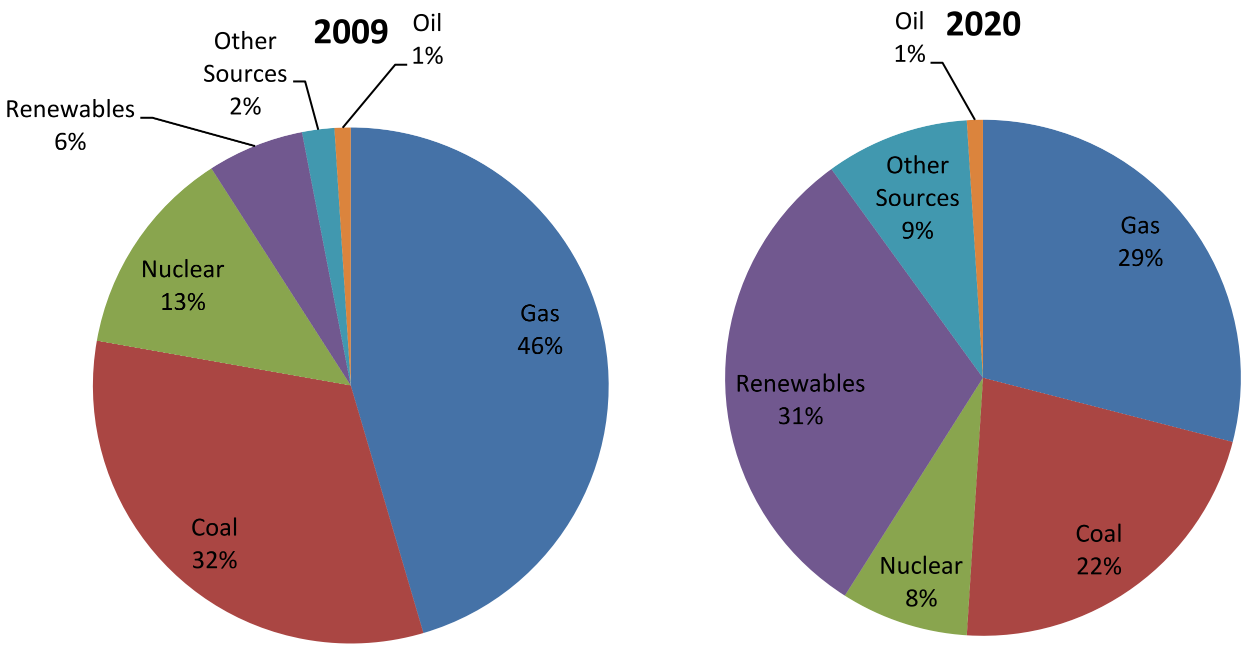


**Figure 1 Pie chart showing the makeup of our electricity supply in 2009 and that predicted for 2020. Adapted from Energy Trends (2009) and Department for Business Innovation and Skills (2009), cited in HM Government, 2009.**

With around sixteen power stations, generating approximately a quarter (18GW) of the UK's electricity, planned for closure by 2018, the need for cleaner and more diversified energy sources is a growing imperative. Renewable electricity generation has already been rising fairly rapidly, and since the introduction of the RO, it has increased from 1.8 per cent in 2002 to 5.3 per cent of total UK electricity generation in 2008 (HM Government, 2009a). Against this backdrop of growing renewable energy investments, this report focuses on the development of biomass energy in the UK, which as Figure 2 shows, already makes up an important contribution to the renewable electricity portfolio.

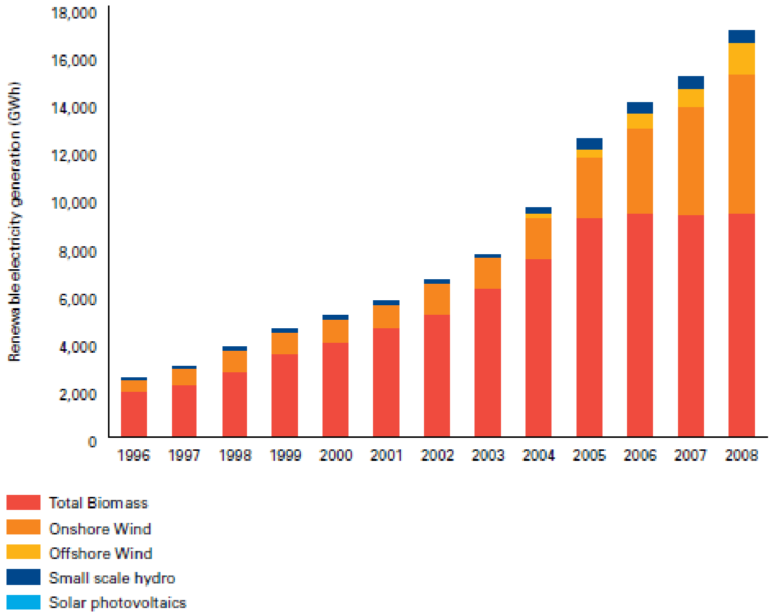


**Figure 2 Graph showing the rise of renewable electricity generation since 1996. Taken from Digest of UK Energy Statistics (2009), cited in HM Government (2009a)**

It begins by providing an introduction to biomass energy and goes on to discuss the level of development it has seen in the UK. In chapter four, it takes a look at the current and projected national sources of biomass, and their associated Greenhouse Gas (GHG) emissions. Some of the barriers to the biomass energy sector are discussed and towards the end, lessons learned from our own development path here in the UK that could be useful for developing countries are presented.

# 2 What is biomass energy?

Biomass is an important renewable energy source, which the UK Government recognises as one solution to reaching a low carbon economy (DEFRA, 2007b). The UK Biomass Strategy (2007, p11) define biomass as "any biological material, derived from plant or animal matter, which can be used for producing heat and/or power, fuels including transport fuels, or as a substitute for fossil fuel-based materials and products". Essentially, it is considered a carbon neutral resource because the carbon dioxide ($CO_2$) emitted during energy production is reabsorbed during growth of the crop (DTI and DEFRA, 2007). Emissions released during the establishment, harvesting, production, supply and transport phases however, result in a slight positive overall contribution of $CO_2$ emissions (PB Power, 2008). GHG savings are one of the main drivers of biomass energy but its use can also contribute to socio-economic opportunities within rural areas, as well as increasing diversity and security of energy supply, through reduced reliance on imported fossil fuels (MacLeod *et al*., 2005; DTI and DEFRA, 2007).

Compared to other renewable energy sources, biomass energy has the following characteristics:

- It releases a significant amount of heat, which if harnessed can increase efficiency significantly (MacLeod *et al*., 2005).
- Most biomass feedstock involves a cost (MacLeod *et al*., 2005), with fuel costs contributing up to 90 per cent of the total operating costs (Forestry Commission, 2010b).
- The need for biomass storage can involve additional capital costs (MacLeod *et al*., 2005).

- There are no problems of intermittency and therefore controlled and continuous power generation is possible (MacLeod *et al*., 2005;RCEP, 2004).
- It is more employment intensive per unit of energy than other renewables (IEA, 2003, cited in EUBIA (2007); IEA (2007)) through engagement of different parts of the supply chain[1]. It is difficult to provide an exact figure for the UK, as there is a significant lack of data on the level of employment in the biomass energy sector, but an indicative calculation using preliminary data from the Biomass Energy Centre on the number of people directly and indirectly employed in the woodfuel industry alone shows that 91.8 people are employed per 100 GWh[2]. For the entire biomass energy sector this figure would be even higher[3].
- Flexibility in the technology choices: it can be used in both urban and rural environments, at different scales (domestic, commercial or industrial) and for electricity, heat or transport (RCEP, 2004; DTI and DEFRA, 2007; HM Government, 2009b).

As with most renewable technologies, biomass plants generally require greater capital investment than fossil fuel based heating technologies, which RCEP (2004) predict to be two to three times greater; but the cost of biomass fuel is cheaper than fossil fuels. The Bio-Energy Capital Grants Scheme is intended to help with these high upfront costs.

The calorific value of biomass is rather low compared to other fuels and its water content quite high, therefore it requires a certain amount of drying (RCEP, 2004). Moreover, biomass materials have fairly low densities and, depending on the type of feedstock, the cost of transport is affected by volume rather than weight, with transportation costs making up a large proportion of overall supply cost (DTI, 2007). Densities can vary greatly between feedstocks due to differences in moisture content (MC) and packing densities. For example, freshly harvested and chipped Short Rotation Coppice (SRC) Willow, with a high moisture content has an approximate density of 0.14 (dry matter)/$m^3$, compared to the high densities of dry wood (0.4-0.5t/$m^3$) (DTI, 2007).

## 2.1 Sources of Biomass

Various different sources of biomass exist, ranging from virgin wood, energy crops such as miscanthus and willow, and biomass waste (see figure 3). Some of these can be processed into various physical forms such as wood chips or pellets. Section 4 goes on to provide more details about some of these biomass sources in the UK.

Different biomass sources are suitable for different types of energy use. For example, energy crops can be grown on a large scale and are thus suitable for medium to large-scale generators, whereas the more dispersed nature of forestry products (such as sawdust) makes them more suitable for small to medium-scale energy generation (RCEP, 2004). Competition may exist for forestry materials from other end uses, such as in saw mills, but in some cases these process themselves may generate by-products which can also be used as a biomass fuel (as seen with the RWEnpower 50 MW plant in Fife, spreadsheet 1[4]). Waste biomass is thought to be deeply underutilised, with only around 25 per

[1] Production, harvesting, processing, storage, transportation and final conversion.
[2] Details of this calculation are found in Annex 1.
[3] It is worth noting that this final figure could vary depending on how 'indirect' and 'direct' related jobs are defined and the different methodologies used (REN21, 2010).
[4] Spreadsheets referred to throughout this document are available on request from the author. They are as follows: 1. List of energy companies and their biomass power plant developments; 2. List of biomass related associations in the UK; 3. List of grants available for biomass energy.

cent of the five to six million tonnes of waste wood generated each year recovered in 2004, of which much of the remainder ended up in landfill (MacLeod *et al*., 2005). Contaminated waste wood  or solid recovered fuels are required to comply with the Waste Incineration Directive (WID), which has to a certain extent deterred its use as an energy source (MacLeod *et al*., 2005; Forestry Commission, 2007; DTI and DEFRA, 2007). A large amount of straw also exists in the UK - around 24 million tonnes in 2002 - which is a generally accepted resource among farmers, although in common with forestry materials, it also has various different end uses (RCEP, 2004).

**Figure 3 Sources of biomass. Created by author using content from Biomass Energy Centre (2008b)**

**Virgin Wood**
- Untreated and clean
- Suitable for a range of energy applications

→ **Wood from forestry**
→ **Wood processing industry co-products**
→ **Wood from arboricultural arisings**

**Available in a range of physical forms:**
a. bark
b. brash
c. logs
d. sawdust
e. wood chips
f. wood pellets and briquettes

**Energy Crops**
- Grown specifically for use as fuel
- Offer high output per hectare with low inputs

→ **Agricultural energy crops:**
a. sugar crops; b. oil crops; c. starch crops

→ **Grasses and non-woody energy crops:**
a. miscanthus; b. hemp; c. other grasses e.g switchgrass, reed canary grass, rye, giant reed

→ **Short rotation energy crops:**
a. short rotation forestry (SRF) e.g: eucalyptus, *Nothofagus* (southern beech), poplar, sycamore, ash;
b. short rotation coppice (SRC): poplar and willow

**Waste and residues**

**Agricultural Residues**
- Wide variety of types
- Energy conversion technologies and handling protocols vary between types

→ **Wet residues:**
a. animal manure and slurries; b. grass silage

→ **Dry residues:**
a. arable crop residues such as straw or husks; b. corn stover; c.animal bedding such as poultry litter

**Food Waste**
- Waste produced in the food supply chain
- In the UK, approx. 1/3 of total food grown for human consumption is disposed of
- UK households produce approx. 5 mill tonnes of kitchen waste/yr.

→ **Wet food waste from**:
a. food processing and manufacturing

→ **Waste oils**

**Industrial Waste and Co-Products**
- Various industrial processes and manufacturing operations produce residues, waste or co-products that can potentially be used or converted to biomass fuel

→ **Woody waste and residues:**
a. untreated wood; b. treated wood wastes and residues; c. wood composited and laminates

→ **Non-woody wastes and residues:**
a. paper pulp and wastes; b. textiles; c. sewage sludge

**POPLAR**
Crown Copyright. Forestry Commission Picture Library/ Thelma Evans

**WASTE WOOD**
Crown Copyright. Forestry Commission Picture Library/ George Gate

**MISCANTHUS**
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## 2.2 Biomass energy processes

Figure 4, below, provides a breakdown of the range of biomass resources, supply systems, conversion technologies and end uses that can be found within the biomass energy sector. Due to time constraints of this paper, in the following chapter the focus is primarily on electricity and heat generation, as these are two of the most widely used forms of biomass energy.

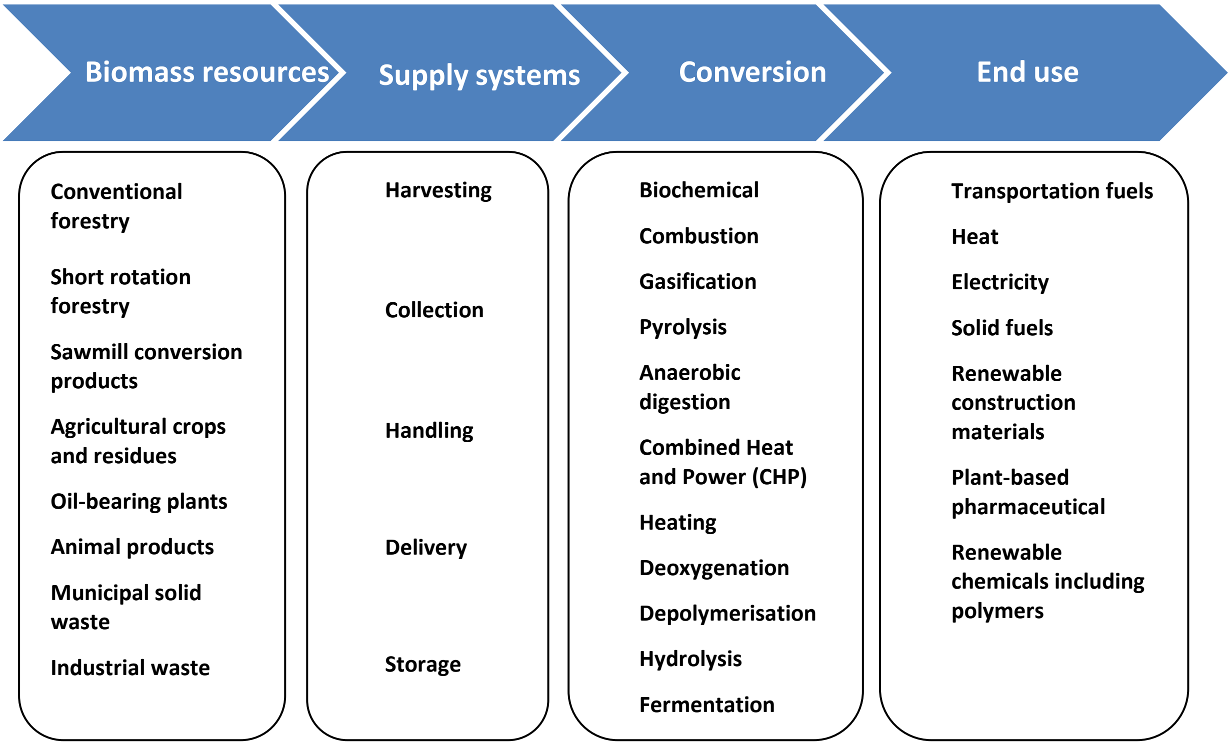



**Figure 4 Breakdown of the main pillars of biomass energy production. Adapted from DTI and DEFRA (2007)**

An outline of the main processes that generate heat and/or electricity is shown in Box 1. Combustion is one of the more established technologies but due to its low efficiency, additional research is now being directed at other more efficient technologies such as gasification (DTI and DEFRA, 2007).

**Box 1 Typical processes used for bio-energy heat and power generation. Content quoted from NNFCC (2009b), RCEP (2004), DTI and DEFRA (2007).**

- **Combustion**
  Biomass can be burned on its own or in combination with coal (co-fired: up to 15 per cent biomass can be used in a typical coal-fired power station). This produces heat and generates electricity via a steam turbine. Energy conversion efficiency: approximately 30-45 per cent
- **Gasification**
  Biomass can be gasified to form syngas, which can be burned to produce heat and power via a gas turbine. Combined cycle gas turbines can increase the energy conversion efficiency of biomass substantially. Energy conversion efficiency: 60-80 per cent.
- **Anaerobic digestion**
  Biomass is placed in sealed vessels and is digested by microorganisms. The by-product of this digestion is methane, which can be burned to provide heat and power or processed into transport fuel and chemicals. The NNFCC is working with Environmental Protection UK to develop biomethane as a transport fuel in the UK.
- **Combined Heat and Power (CHP)**
  CHP systems harness the heat generated as a by-product during electricity generation. The heat can be used onsite (for example, in a distillation process) or by nearby industry or housing. District heating (the transfer of heat to houses via pipelines) is used widely in some European countries, such as Denmark, but has yet to become established in the UK. CHP can increase energy conversion efficiencies to up to 85 per cent, and significantly reduce GHG emissions.
- **Heating**
  Provides heat output only. Often used in domestic or community level boilers. Provide efficiencies, the same as or higher than CHP.
- **Pyrolysis**
  Pyrolysis involves heating the fuel without air or steam, to decompose it and drive off volatile combustible gases. Conversion efficiency: 75-80 per cent.

The cost-effectiveness of the different technologies is largely dependent on the efficiencies that can be achieved but could also vary depending on the energy demand from surrounding communities, the scale of the plant, and the MC and level of processing of the biomass feedstock (DTI and DEFRA, 2007).

## 2.3 Cost of different sources of biomass

With biomass energy still at the early stages of development, the cost of biomass feedstock has been widely variable; and in terms of availability, density and level of production and there is uncertainty over how these prices will continue to change in the long-term (DTI, 2007; RCEP, 2004). There have been attempts to estimate the cost of different types of biomass, and a summary is shown in table 1 (DTI, 2007). Pellets are the most expensive fuel choice due to the level of additional processing involved, but it should be noted that the capital cost of pellet boilers is lower than that of wood chip boilers (DTI, 2007). Woodfuel logs and straw are the cheapest resources but the use of logs is limited, since community and domestic biomass boilers often require more processed fuel types and logs are also more difficult to transport. Waste wood and arboricultural arisings are also relatively cheap options, as they would usually otherwise be sent to landfill.

**Table 1 - Summary of biomass fuel costs, excluding transport and delivery unless otherwise stated. Taken from DTI (2007). Numbers in brackets are prices in £/oven dried tonne (odt). Woodfuel = forest woodfuel, sawmill co-product, arboricultural arisings and clean waste wood.**

| Biomass type | Central price (£/GJ) | Price range (£/GJ) |
|---|---|---|
| Forestry woodfuel – chips | 2.5 (60) | 2.0-3.0 |
| Forestry woodfuel – logs | 2.0 (40) | 1.5-2.5 |
| Energy crops | | |
| SRC | 3.5 (70) | 3.0-4.0 |
| Miscanthus | 3.0 (53) | 2.5-3.5 |
| Arboricultural arisings | 2.5 (49) | 2.0-3.0 |
| Straw | 2.0 (35) | 1.5-2.5 |
| Waste wood (clean) | 2.5 (49) | 2.0-3.0 |
| Waste wood (contaminated) | 1.0 (20) | 0.5-1.5 |
| Pellets to power/industry/commercial from woodfuel | 4.5 (90) | 4.0-5.0 |
| Pellets to power/industry/commercial from SRC | 5.5 (110) | 5.0-6.0 |
| Pellets to power/industry/commercial from miscanthus | 5.0 (100) | 4.5-5.5 |
| Pellets to domestic (including delivery) | 7.0 (140) | 6.0-8.0 |
| Imported biomass (including delivery) | 4.5 (90) | 3.5-5.5 |

# 3 Level of biomass energy development in the UK

Interest in biomass energy in the UK as a sustainable renewable energy option has grown significantly over the past decade but we are still far from meeting the level of development shown by some of our European counterparts (Forestry Commission, 2007). Nevertheless, the Renewable Energy Strategy (HM Government, 2009b) states that biomass for heat and power has the potential to meet just under a third of the 2020 UK renewable energy target. A summary of the renewable energy utilisation in 2008 is shown in figure 5, highlighting the substantial contribution from biomass from a range of different sources.

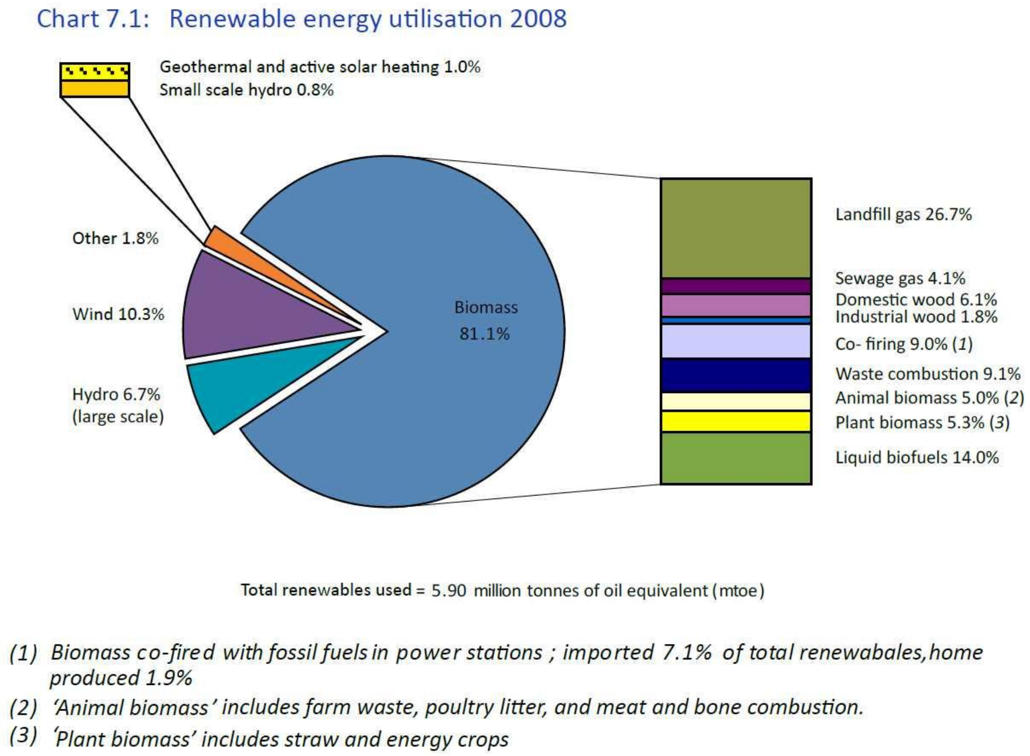



**Figure 5 Renewable energy use in 2008. Adapted from (DECC, 2009b).**

In 2007, biomass made up three per cent of the total UK energy supply (Forestry Commission, 2007) and according to RCEP (2000), by 2050 this could reach up to 12 per cent. Biomass generated electricity has received much more support in the UK than heat or CHP, despite the higher conversion efficiencies of the latter. In 2005, about 3.5 per cent of electricity and 0.6 per cent of heat was produced from bio-energy (DTI and DEFRA, 2007). Reasons for this uneven level of support include a lack of policies for heat generation and the greater versatility of electricity generating plants in terms of their location. This is because heat or CHP plants need to be located closer to areas of concentrated heat demand, such as adjacent to a housing, retail or industrial park development; while electrical transmission lines are less site specific and offer more flexibility at a lower cost than heating distribution networks (RCEP, 2004).

With biomass energy in the UK still at a relatively early stage of development, there has been criticism from MacLeod *et al.* (2005) that the development path pursued so far has been rather fragmented. Aside from the lack of support for biomass heat, other problems include poor development of the supply chain, a lack of awareness and understanding, disjointed government support and policies, complex grant support, slow progress of UK supply stocks, and widely variable costs and performance, which are discussed in more detail throughout this paper (DTI, 2007).

## 3.1 Electricity generation

As mentioned above, primary focus and support for biomass has so far been directed at electricity generation through policies such as the RO, resulting in slow uptake and development of heat and CHP. The RO commits electricity suppliers during an obligation period to generate an increasing proportion of their electricity from renewable energy through the purchase of a pre-determined number of Renewables Obligation Certificates (ROCs) from renewable energy generators (HM Government, 2009a; DECC, 2009a; OPSI, 2009). Where suppliers are unable to produce the correct amount of ROCs, they are required to pay a penalty, which then gets circulated back to those suppliers who were able to present ROCs. In the past, a percentage was used to reflect the size of the obligation but since the introduction of banding in 2009 this has been revised, and now the obligation is determined by a set number of ROCs for each electricity supplier. In other words, "these percentages have been transformed into a level of ROCs per MWh of electricity sales by licensed suppliers" (DECC, 2009a, p2), as seen in table 2, which provides figures for the increasing levels of ROC obligation until 2016. These figures are then used to determine the total number of ROCs to be produced by designated electricity suppliers for the obligation period concerned, after which the number of ROCs required from each electricity supplier per MWh can be calculated[5]. For example, running the figure for the current 2010-2011 period (0.104MWh) through the calculations, the Supplier's Obligation of Sales is 0.111 ROCs per MWh.

**Table 2 ROC Obligation. Adapted from (OPSI, 2009).**

| Obligation Period | Number of ROCs per megawatt hour of electricity supplied in Great Britain (figure in brackets approximately % of renewable electricity) | Number of ROCs per megawatt hour of electricity supplied in Northern Ireland (figure in brackets approximately % of renewable electricity) |
|---|---|---|
| 1st April 2009 to 31st March 2010 | 0.097 (9.7%) | 0.035 (3.5%) |
| 1st April 2010 to 31st March 2011 | 0.104 (10.4%) | 0.040 (4 %) |
| 1st April 2011 to 31st March 2012 | 0.114 (11.4%) | 0.050 (5%) |
| 1st April 2012 to 31st March 2013 | 0.124 (12.4%) | 0.063 (6.3%) |
| 1st April 2013 to 31st March 2014 | 0.134 (13.4%) | 0.063 (6.3%) |
| 1st April 2014 to 31st March 2015 | 0.144 (14.4.%) | 0.063 (6.3%) |
| 1st April 2015 to 31st March 2016 | 0.154 (15.4%) | 0.063 (6.3%) |

Under the RO, biomass qualifies as a renewable energy source if at least 90 per cent of its energy content comes from biomass (OFGEM, 2009) (lowered from 98 per cent originally). Until recently, one ROC would be issued per MWh of eligible renewable electricity generation regardless of the renewable energy technology used; in 2009 this was reviewed to allow renewable energy technologies to be banded into different categories. This meant that well established technologies, such as co-firing, receive lower ROC support per MWh than dedicated biomass burning of energy crops (see table 3). This is a way of providing targeted levels of support to technologies at different stages of development.

**Table 3 ROC banding between different renewable technologies. Adapted from BERR Renewables Obligation Consultation, cited in the Carbon Trust (2010).**

| Band | Technologies | Support ROCs/MWh |
|---|---|---|
| Established 1 | Landfill gas | 0.25 |
| Established 2 | Sewage gas; co-firing on non-energy crop (regular) biomass | 0.5 |

[5] The calculations used can be found in articles 6-12 of the Renewables Obligation Order 2009 (OPSI, 2009).

| | | |
|---|---|---|
| Reference | Onshore wind; hydro-electric; co-firing of energy crops; EfW with combined heat and power; geopressure; other not specified | 1 |
| Post-demonstration | Dedicated regular biomass | 1.5 |
| Emerging | Offshore wind; wave; tidal stream; advanced conversion technologies (anaerobic digestion; gasification and pyrolysis); dedicated biomass burning energy crops (with or without CHP); dedicate regular biomass with CHP; solar photovoltaic; geothermal; tidal lagoons; tidal barrages (<1GW) | 2 |

The RO was originally set to end in 2027, but as of April this year it has been extended until at least 2037 (DECC, undated), as a way of providing long term certainty for investors.

Electricity can also be generated through co-firing biomass with coal, a process that was envisaged to help kick start the biomass energy sector in the UK by developing supply chains and building up energy crops. This was due to come to an end in 2016 once the biomass energy sector and its infrastructure had become more established. The deadline has since been retracted however, because the importance of co-firing in developing the biomass energy sector has now been recognised. Licensed electricity suppliers currently have a cap, which limits the proportion of electricity that can be generated from a co-firing plant, which in 2009 was 10 per cent of the supplier's total RO, now increased to 12.5 per cent (Oxera, 2009). The cost effectiveness of co-firing depends on a number of factors, including the type of fuel used and the percentage of total fuel input it contributes (DTI, 2007).

Woods *et al*. (2006) estimate that in 2005, over half of the biomass used in co-firing was imported (approximately 0.76 million tonnes out of a total 1.4 million tonnes). Table 4 provides a breakdown of different co-fired feedstock and their likely country of origin, as well as any transport related emissions. The majority of the feedstock used (31.8 per cent) is made up of palm residues sourced from overseas. Compared to locally grown energy crops, the total transport related emissions are approximately 63 times greater. Reasons for higher levels of imported feedstock include their competitive price and the relatively limited availability of feedstock such as energy crops in the UK. With much of imported biomass sourced from developing and middle income countries, there is a concern as to whether this is all produced sustainably and the potential impacts the production of these feedstocks may have at the community level. Moreover, this could present a loss of potential for host countries to harness this feedstock for their own use and biomass energy development. It is likely that imported supplies will continue to make up a significant amount of overall co-fired biomass supplies but the exact amount will ultimately depend on the level of competition between different biomass feedstocks and the extent to which indigenous supplies continue to develop here in the UK (DTI and DEFRA, 2007). To overcome the issue of sustainability, the UK government now demand annual reports outlining the extent of biomass used, where it is sourced and compliance with any accreditation schemes to be submitted to the Regulator (DTI and DEFRA, 2007).

There is still an air of concern that too much focus on co-firing can divert interest from investing in biomass dedicated generation plants. It is likely, however, to continue to play an important role in the short to medium term in helping to establish biomass supply chains, whilst the biomass sector continues to become more developed and better coordinated (RCEP, 2004).

**Table 4 Different types of feedstock used for co-firing in 2005, and their transport related emissions. Data taken from Woods *et al*. (2006) and assimilated by DTI and DEFRA (2007).**

| **Feedstock** | **Quantity burned (tonnes) in** | **% quantity burned (tonnes) in** | **Likely country of origin** | **Mode of transport** | **Total transport-related emissions (kg $CO_2$/tonne biomass)** |
|---|---|---|---|---|---|

| | 2005 | 2005 | | | |
|---|---|---|---|---|---|
| Energy crops (SRC, granulated willow, miscanthus) | 4,306 | 0.3 | UK | Road | 1.7 |
| Shea residues (meal and pellets) | 5,420 | 0.4 | Africa | Ship | 55.4 |
| Sunflower pellets | 20,331 | 1.4 | Romania | Road & ship | 47.1 |
| Sewage sludge and waste derived fuels | 49,155 | 3.5 | UK | Road | 3.4 |
| Cereal co-products and pellets | 102,246 | 7.2 | UK | Road | 1.7 |
| Tallow | 119, 828 | 8.5 | UK | Road | 1.7 |
| Olive waste (residue and expeller) | 283,222 | 20.1 | Greece, Italy, Spain | Road & ship | 21.2 |
| Wood (sawdust, chips, pellets, tall oil) | 377,956 | 26.8 | UK, Canada, Latvia, Scandinavia | Road & ship | 1.7 (UK) to 42.9 |
| Palm residues (palm kernel expeller, shell, pellets, oil) | 449,657 | 31.8 | Indonesia, Malaysia | Road & ship | 106.5 (Indonesia) to 107.4 (Malaysia) |
| Total mass | 1,412,121 | | | | |
| Total energy (PJ) | 14.1 | | | | |

## 3.2 Heat generation

After much pressure from the biomass energy sector to provide renewable heat with the same level of support as electricity generation, in April 2011 the UK government will introduce the Renewables Heat Incentive (RHI) to provide long-term revenue for the use of renewable heat, including that generated by biomass (Forestry Commission, 2010a). All scales of renewable heat (domestic, community or industrial) are expected to be eligible under the RHI, and similar to the RO, it will also be banded depending on the size and technology (Forestry Commission, 2010a). To complement improved policy for biomass heat, a growing number of grant schemes are beginning to provide support for heat energy, such as the Biomass Heat Accelerator Project, the Low Carbon Buildings Programme for domestic installations (DTI and DEFRA, 2007) and the Bio-Energy Capital Grants Scheme (spreadsheet 3). Other policies that commit the UK government to pursuing renewable heat solutions include the Climate Change and Sustainable Energy Act (DTI and DEFRA, 2007).

## 3.3 The UK government and biomass energy

There are several governmental departments responsible for the development of biomass energy but there are criticisms that each has a different agenda, and that what has so far been lacking is coherent ownership of biomass-related policies (MacLeod *et al*., 2005). One issue has been that biomass energy not only involves energy and climate change policy but also rural development, waste and non-food crops policy, all of which are governed under different departments, such as the Department of Environment, Food and Rural Affairs (DEFRA), the National Non-food Crops Centre (NNFCC) and previously by the Department of Trade and Industry (DTI).

There have been many changes in government departments over the last few years and in 2008, the Department of Energy and Climate Change (DECC) was created, merging energy and climate change mitigation policy. Within the DECC, the Office of Renewable Energy Deployment (ORED) was introduced to carry out the commitments identified in the the UK's Renewable Energy Strategy (ORED, Undated). Moreover, in response to the Biomass Task Force report which identified the lack of a national central information hub, the Biomass Energy Centre was created. Run by the Forestry Commission, it acts as a central biomass energy information point for farmers, industry and the public, with guidance on a range of different issues (DEFRA, Undated; Forestry Commission, 2007), operating in a complementary manner to the NNFCC (NNFCC, 2009b). RCEP (2004) suggested the establishment of a discussion forum, to allow different stakeholders throughout the country to share ideas and identify potential problems; at the end of 2009, the UK Government (DECC and DEFRA) set up a forum entitled the Biomass Sustainability Working Group (HM Government, 2009b). As some of these departments have been only recently formed, the next few years will be an opportunity to assess their effectiveness and identify any further improvements that need to be made.

The Carbon Trust and the Energy Savings Trust have dedicated part of their work to biomass energy, and have so far served as a medium between local delivery and government policy, with the former assisting business and the public sector and the latter households, small businesses and the public sector (MacLeod *et al*., 2005). Both support the development of low carbon technologies, including biomass, and are expected to play an important role in further developing the market and in raising awareness about biomass energy.

Regional Development Agencies (RDA) are central in helping to achieve national policy goals through focused regional delivery of carbon targets; development of local supply chains; and identification of regional infrastructure needs, local biomass resources and markets for heat and electricity (MacLeod *et al*., 2005; DTI and DEFRA, 2007; RCEP, 2004). To achieve this, the UK Biomass Strategy (DTI and DEFRA, 2007) expect RDAs to work together in a more harmonised way with the Forestry Commission and local authorities, as well as local delivery bodies.

## 3.4 Biomass power plants in the UK

The past five years has seen a growing number of medium to large-scale facilities come into planning and development from a wide range of energy companies (see spreadsheet 1), with capacities having expanded substantially from approximately 30 MW in 2005 (MacLeod *et al*., 2005) to current projects in development reaching 300 MW (figure 7b). Figure 6 shows the biomass power plants currently in operation in the UK (burning approximately one million tonnes of biomass (Bonsall, 2010)) and the maps below display the medium and large-scale plants in the planning stage (figure 7a and 7b). The following boxes explore four case studies in more detail: two operational biomass power plants as well as a small and large-scale biomass power plant in planning.

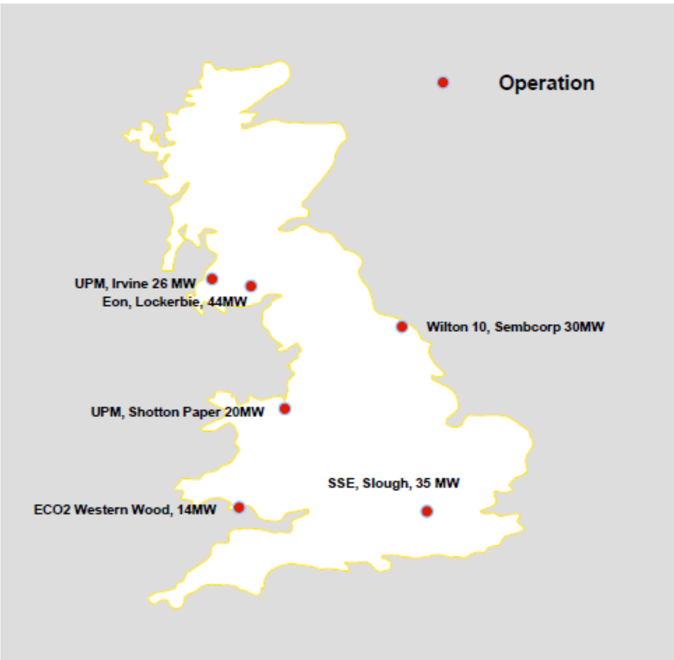



**Figure 6 Biomass power plants currently in operation. Taken from Bonsall (2010)**

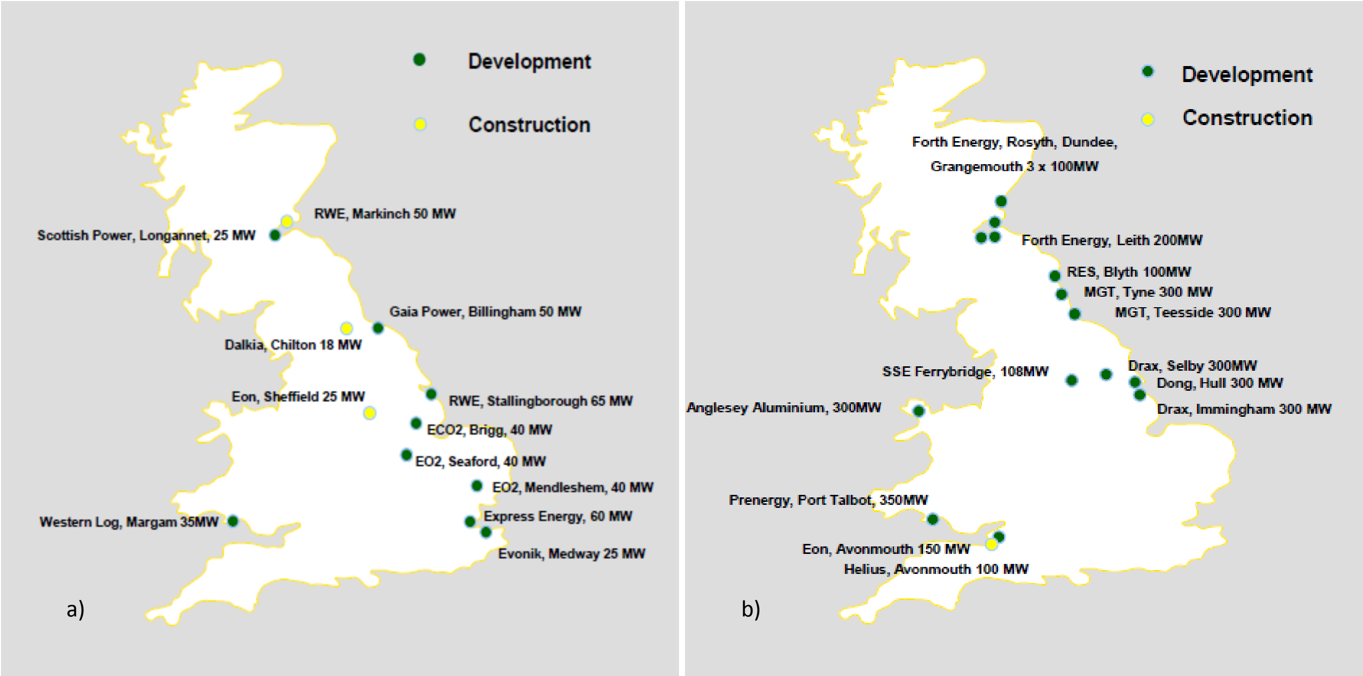



**Figure 7 a) medium and b) large biomass power plants under development or construction. Updated from Bonsall (2010)**

**Box 2 Case study of an existing biomass power plant in the Tees Valley (Sembcorp, Undated).**

In the Tees Valley, Sembcorp invested in a £60 million 30MW biomass power station (£12 million of which was provided by the Bio-energy Capital Grants Scheme), which became operational at the end of 2007. At the time of opening it was the UK's "first large scale wood to energy plant" (Sembcorp, undated), using 300,000 tonnes of wood (150,000 odt).

**$CO_2$ emission savings are approximately 200,000 T/yr compared to a similar sized fossil fuel power station.**

**The two year construction period provided around 1,000 jobs, with 15 permanent jobs created for the operation of the plant. In addition to this, jobs have also been created through the farming, forestry, wood recycling and transport sectors.**

This biomass power plant is able to use a range of biomass fuels, and the four wood products chosen are identified below, all sustainably sourced from the UK through contracts based on long term wood supplies from surrounding areas. These fuels are blended before combustion on site.

**FUEL TYPE**

**Short rotation willow coppice**

55,000 tonnes per year by 2011 of this source, supplied as woodchips. As it is still being grown, alternative fuels are required.

**Small roundwood logs**

80,000 tonnes of mixed hardwood and softwood, sourced from commercially managed forests and chipped on site.

**Sawmill co-products**

80,000 tonnes, including offcuts, supplied as chips.

**Recycled wood**

80,000 tonnes of recycled wood, supplied as woodchips from UK Wood Recycling Limited. This includes a certain amount of sheet materials and demolition timber.

**Box 3 Case study of an existing biomass power plant, Steven's Croft (E.ON UK, Undated-b; E.ON UK, Undated-a; E.ON UK, Undated-c)**

Steven's Croft is E.ON's 44MW biomass power station, which officially opened in March 2008. It produces enough power for 70,000 homes and the annual displacement of $CO_2$ emissions is estimated to be 140,000 tonnes. The total investment to build this plant was £90 million. In 2007, it was awarded 'Scotland's best renewable energy project', at Scottish Renewables' Green Energy Awards.

This plant requires more than 480,000 tonnes of fuel per year, which is made up of three sources:

- **60% sawmill co-products and small round wood pellets**
- **20% short rotation coppice (willow)**
- **20% recycled fibre (from wood product manufacture)**

It is hoped that within four years of operation, 90,000 tonnes per year of locally sourced willow will be used for the plant.

The benefits to the local and regional economy are clear, with 40 jobs created directly at the plant and up to 300 jobs created indirectly in the local forestry industry. It also provides a market for the by-products of the local timber industry and for energy crops from local farmers.

**Box 4 Case study of a small scale biomass plant in planning (Evonik, 2010; Evonik, Undated; Evonik, Undated,)**

The UK generates more than six million tonnes of non-recyclable waste wood annually, with much of this ending up in landfill. With landfill tax still rising, however, the overall costs are becoming increasingly high. Kent produces more than 100,000 tonnes of waste wood annually, with the majority currently going to landfill; there is therefore great potential to use this resource in a more sustainable way.

**Non-recyclable waste wood diverted from landfill, would result in annual savings of approximately 540,000 tonnes of $CO_2$.**

In early 2010, Biomass Power Plant Ridham Ltd, a subsidiary of Evonik New Energies and HES Biopower, submitted a planning application to Kent County Council for the construction of a small scale biomass CHP plant. This would generae around 25 MW of power to be exported to the national grid and up to 35MW of low grade steam heat, which could be used by nearby industrial processes. If successful, this plant would be located on the industrial land at Ridham Dock in Kent.

The proposed feedstock includes non-recyclable waste wood, with the plant capable of processing up to 160,000 tonnes annually. The outcome of the planning application is hoped to become available later this year.

As part of the planning process, an in-depth consultation process was carried out prior to submission of the planning application within the local community, to ensure that plans will be transparent and take into consideration any concerns that may arise from local business and residents. This involved a public exhibition, distribution of newsletters and presentations, with all the information made available in the public domain.

**This plant would result in up to 30 permanent local jobs for operation of the plant, temporary construction work and also local investment through long-term contracts with surrounding companies for services and materials.**

**Examples of non-recyclable wastewood**

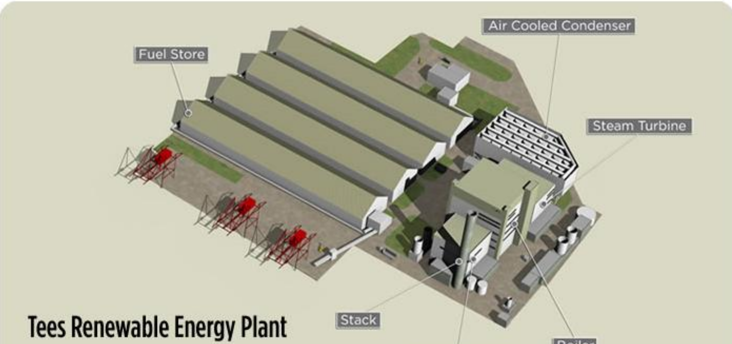
- **Chipboard**
- **Plywood**
- **Melamine coated (kitchen units)**
- **Medium-Density Fibreboard (MDF)**
- **Painted**
- **Varnished**
- **Treated wood form construction & demolition**
- **Industrial uses**
- **Civic amenitities**

If the planning application is successful, it is expected that construction will start in spring 2011, with a fully operational plant by the end of 2012.

**Box 5 Case Study of a large scale biomass energy plant in planning, Teeside Renewable Energy Plant, MGT Power. Source: (MGT, Undated-a) and (PB Power, 2008).**

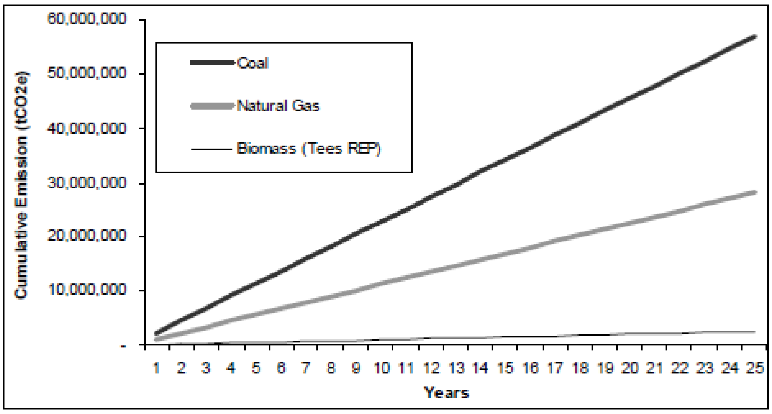
Approval was given in July 2009 for the construction of a 300 MW biomass fired renewable energy power station, expected to be the largest biomass boiler in the world, situated close to Teesport (Redcar and Cleveland Borough). The total investment is over £400 million. It is hoped that construction will commence mid-2010, subject to confirmation of contracts, and that it will be fully operational by 2013.

The main feedstock will be 2.4m tonnes of clean woodchip per year from sustainable forestry products, both from plantations and sustainably managed and certified forests, with the encouragement of marginal land use. This would be sourced mainly from Europe and North America under long term contracts, which makes its location adjacent to a port particularly ideal. For it to operate continuously, it will require 200,000 tonnes of storage space on site. The technology used will be a wood chip fed single circulating fluidized bed boiler, which will generate steam and thus electricity by turning a turbine connected to a generator.




Source: http://www.mgtteesside.com/

Although this biomass plant will lead to $CO_2$ savings, there are nevertheless emissions released in the transport phase of the feedstock (primarily if shipped from overseas) as well as from the establishment, cultivation and harvesting of biomass fuel. These are shown below in $CO_2$ per tonne of biomass. The graph shows the cumulative $CO_2$ emissions from the TEES biomass plant compared to fossil fuel alternatives.




**Emissions**

- **Transport: a) North America (6,500km), 49.2 kg $CO_2$ b) EU (1,400 km), 14.2 kg $CO_2$**
- **Cultivation: 18 kg $CO_2$**
- **Harvesting and chipping: 26kg $CO_2$**

**UK benefits**

- 5.5% contribution to the UK's Renewable Obligation target in 2012
- improved energy security through reduced reliance on imported gas
- savings of 1.2m tonnes of $CO_2$ annually and up to 52m tonnes over its lifetime
- production of reliable and secure electricy source for the national grid
- will supply 3% (2.4 TWh) of the bio-energy target in the Renewable Energy Strategy

**Local benefits**

- part of the £30m/yr operational costs and £400m initial investment will be spent in the local economy, through locally sourced matereials and locally based contractors.
- local employment: 600 jobs during construction, 150 on-site permanent local jobs and up to 500 indirect local jobs
- enough power to supply about 600,000 UK households
- minimal nitrogen dioxide and sulphur dioxide emissions through the burning of clean wood chips and advanced technologies

Eventually, a CHP element could be incorporated to this plant to increase its efficiency, however this is very much at the discussion phase. Moreover, it is hoped this plant will trigger the development of a market for locally farmed energy crop biomass, which could provide around 200,000 tonnes per year (about 8% of the required feedstock).

The large number of medium and large-scale biomass power plants in development has attracted concern as to whether there will be a sufficient amount of biomass feedstock to supply all of them. According to Bonsall (2010), the total capacity of biomass power plants currently in development (seen in figure 7a and 7b) exceeds over 7GW, which would require 50-60 million tonnes of biomass annually. This would be five to six times as much as the ten million tonnes of biomass he goes on to predict could be produced in the UK. It is expected that this gap in biomass production levels will be largely met by imported biomass feedstock, which already contributes a large proportion of biomass energy supplies (DTI and DEFRA, 2007). According to the UK Biomass Strategy (DTI and DEFRA, 2007), imported stocks of biomass were equivalent to 54TWh in 2007 and are expected to continue rising in the coming years (DTI and DEFRA, 2007).

The construction of so many biomass power plants is likely to attract public attention and wherever possible they should be carefully designed and located to minimise their intrusiveness (RCEP, 2004). The Teeside biomass plant (box 3), for example, considered the impacts it may have visually on the surrounding areas during its planning process. Smaller plants can help convey a sense of public 'ownership' that is more difficult to achieve with larger plants located further away from the communities that they serve (RCEP, 2004). Public acceptance of biomass power plants will also be partly influenced by the existing energy situation. The benefits of biomass energy are more readily seen, for example, if a newly constructed plant replaces an old and polluting fossil fuel-powered plant (RCEP, 2004). All of the plants currently in development will need planning permission before they reach the construction phase, and over the next few years we expect to begin to better understand some of the constraints identified in this process.

# 4 National sources of biomass feedstock

With such a reliance on imported stocks, the UK government have expressed an interest in greatly expanding national biomass stocks for energy in the Defra Non-Food Crops Strategy (DEFRA, 2003), England's Woodfuel Strategy (Forestry Commission, 2007) and the UK Biomass Strategy (DTI and DEFRA, 2007). Building up domestic biomass supplies allows feedstock to be locally sourced, can help increase economic viability and ensures that $CO_2$ emissions are kept to a minimum (RCEP, 2004).

There are various estimations of the potential contribution different sources of biomass could make up in the UK. The UK Biomass Strategy (DTI and DEFRA, 2007), estimate that the technically available biomass resource in the UK (which does not take into account financial and market constraints or biofuel crop production) could potentially reach 8.3 Mtoe (96.2 TWh of primary energy), if all of the strategies to increase UK biomass stocks were to be adopted. A breakdown of the different fuel types is provided in figure 8.

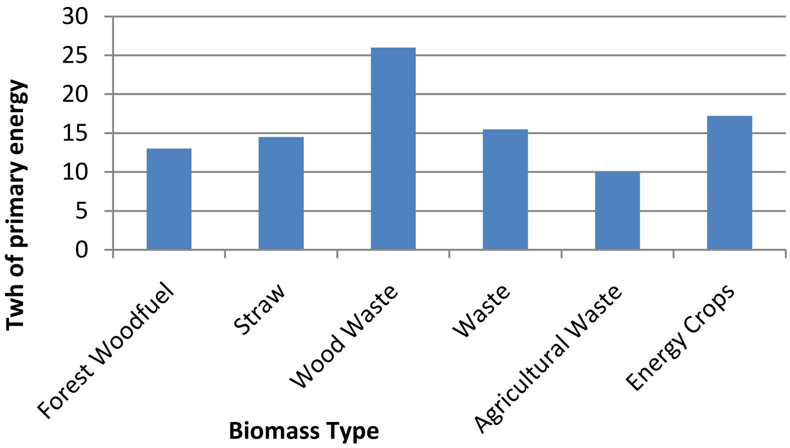



**Figure 8 Chart showing the estimated technical potential of different biomass feedstock. Created by author, using data from DTI and DEFRA (2007).**

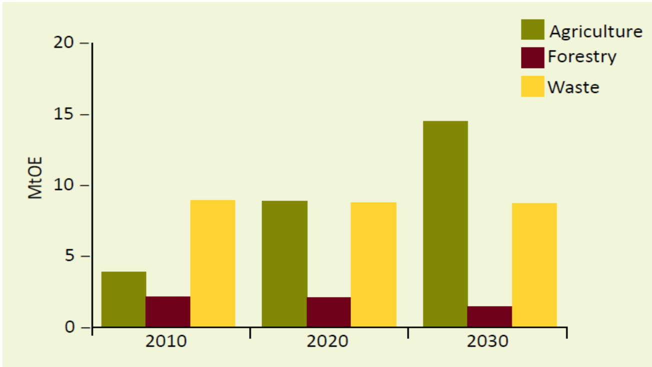



**Figure 9 Bioenergy potential in the UK that could be achieved under good environmental practice. Taken from DTI and DEFRA (2007) based on EEA data.**

The European Environment Agency (EEA, 2006) provides higher estimates for potential biomass in the UK, if produced in an environmentally sensitive manner. Figure 9 shows that in the short term, waste biomass has the greatest potential for bioenergy, allowing time for other crops (such as energy crops) to continue building up their supplies over the long-term.

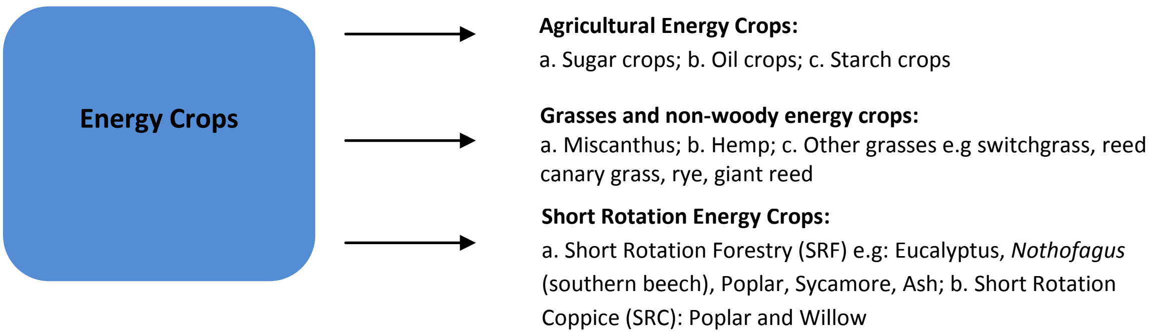
One concern with building up domestic biomass supplies is whether they will be of a sufficient quality over the long term (MacLeod *et al*., 2005). Low quality fuel can decrease efficiencies, raise maintenance costs and even contribute to higher particulate emissions (HM Government, 2009b). Larger plants are better able to demand fuel of a specific quality through their supply contracts, whilst for domestic and community-scale users this is not guaranteed. As the market continues to develop, having a system in place to ensure that material is certified to a sufficient standard or quality, and moisture content is produced to meet users at all scales, is extremely important and can greatly raise consumer confidence (HM Government, 2009b). The Solid Biomass Assurance Scheme provided by the Heating Equipment Testing and Approval Scheme (HETAS) is an example of one such biomass fuel quality scheme (HETAS, Undated). The European Committee for Standardisation (CEN) is also currently developing European standards for solid biomass fuels “in order to facilitate trade, develop markets and increase consumer confidence” (Europa, 2009).

The following chapters go on to discuss the supplies of energy crops, woodfuel and, to a lesser extent, biomass waste in the UK and government projections for increasing these sources of biomass.

# 5 Energy crops

Much attention has been diverted to the use of energy crops, which are still at a fairly early stage of development in the UK but are nevertheless expected to play a vital role in the future expansion of the biomass energy market. Figure 10 shows the three different types of energy crops, previously seen in figure 3. Boxes 6, 7 and 8 discuss examples of SRC willow, miscanthus and poplar in more detail.

**Figure 10 Breakdown of different energy crops (Biomass Energy Centre, 2008b)**



Energy crops grow fairly rapidly and can produce high yields, with low fertiliser and pesticide input (Cocco, 2007; Karp and Shield, 2008) and their level of production is much more concentrated and better controlled compared to other sources of biomass (RCEP, 2004).

The characteristics and growth patterns of energy crops differ extensively from arable crops because:

- they can remain *in situ* for a much longer length of time (7-25 years)
- harvesting takes place during winter / early spring
- they can can reach great heights and are denser (DTI and DEFRA, 2007)
- they have deeper rooting (Lovett *et al*., 2009)

The Biomass Strategy (DTI and DEFRA, 2007) proposes that up to 350,000 ha should be dedicated to energy crop growth in the UK by 2020, approximately six per cent of the UK's arable cropping area, which Lovett *et al.* (2009) believe would not be considered a threat for UK food security. This will be supported by grants such as the Energy Crops Scheme and the EU Energy Aid Payment, as well as the newly banded RO (DTI and DEFRA, 2007).

**Box 6 SRC Willow (Salix spp.) (Biomass Energy Centre, 2008a; RCEP, 2004; PB Power, 2008)**

Willow is a SRC crop that is widely grown in the UK, with various species native to the UK and Europe. It is eligible under the Energy Crop Scheme.

**Characteristics**

- Can reach up to 4m in height during the first year, after which it is cut back to ground level in the first winter. After this, heights can reach up to 7-8m.
- Freshly harvested willow has a high moisture content.
- Typical yields: 7-12 odt/ha/yr.
- Approximate income is > £100 ha/y, as well as that gained from grants and subsidies.
- Has a fairly high water requirement.
- Plantation gradient should not exceed 7%.

**Planting and harvesting**

- Rods or cuttings are used for planting in spring, requiring specialist equipment (which can be more costly), at a density of 15,000 per ha.
- Following coppicing, multiple shoots emerge.
- Harvesting requires specialist equipment and occurs during winter, generally three years following cut back.
- It can be harvested as rods, billets or directly chipped, with the latter done cautiously to avoid composting during storage (can lower the energy content and promote mould formation).
- A plantation may last up to 30 years, after which it needs to be replanted.

**Box 7 Miscanthus (*Miscanthus spp.)* (RCEP, 2004)**

Miscanthus is a well known energy crop, eligible under the Energy Crop Scheme. Although it originates from Asia, the yields under UK conditions are still very high, with *Miscanthus x giganteus* the most commonly grown for biomass production due to its tolerance to cooler UK temperatures.

**Characteristics**

- Can reach up to 3.5m in height and its grasses are woody and perennial.
- As it is a rhizomatous grass (concentrates its nutrient storage in the rhizomes), it requires very little additional nitrogen and nutrients, although it can be more expensive than grasses grown from seeds.
- Typical yields: 12-14 odt/ha/yr.
- Compared to most wood, miscanthus displays a marginally lower calorific value and a higher ash content.
- Uses water fairly efficiently.

**Planting and harvesting**

- Typically, planting occurs in spring at a density of 20,000 per ha and by the end of the summer it has already grown to 1-2m. Harvesting takes place in late winter, with the canes left at only 10mm in diameter, displaying a rather low moisture content.
- Annual harvesting on a miscanthus plantation can take place for 15-20 years, after which it needs to be replanted.
- It can be planted, harvested and stored using widely available equipment and methods.

**Box 8 SRC and SRF Poplar (*Populus* spp.) (Biomass Energy Centre, 2008a; RCEP, 2004; Personal Communication, 2010a).**
Poplar is eligible under the Energy Crops Scheme. It can be grown either as a SRC or a SRF crop, with the main difference being the harvesting regime adopted.

**Characteristics**

- The cuttings display an apical bud at the top of the cutting and it is more difficult to plant than other energy crops. Due to its greater apical dominance, it does not tend to develop multiple shoots following coppicing to the same extent as willow.
- The formation of a large taproot means that after the end of cultivation, it can be quite difficult to remove.
- Typical yields: 8 odt/ha/yr.

**Planting and harvesting**

- Cuttings with an apical bud are used for planting in spring, at a density between 10-12,000 per ha.
- If harvested as an SRC crop then initial cutback occurs in the winter following planting, regrowth occurs as multiple stems with harvesting cycles between four and five years.
- If harvested as a SRF crop there is no initial cutback, which allows growth of a single stem and a longer rotation period of 10-15 years, with the advantage being that harvesting can occur using conventional forestry methods and equipment. Subsequent rotations can occur using the strongest stem from the new growth.

## 5.1 Energy crop plantations in the UK

To date, the most popular energy crop in the UK is SRC willow (*Salix* spp.), followed by miscanthus grass (*Miscanthus* spp.) and poplar (*Populus* spp*.)* (RCEP, 2004). In 2005 there were around 2,500 ha dedicated to SRC and miscanthus plantings, with yields reaching approximately 25,000 tonnes per year (MacLeod *et al*., 2005), and this has expanded to approximately 15,000 ha in England alone (NNFCC, 2009a). One advantage of using willow is that the land can be returned to conventional crop use fairly easily (within one to two years), in comparison with poplar or miscanthus which both form deep roots that are more difficult to remove (RCEP, 2004). Furthermore, previous trials have indicated that poplar is much more site specific, which could prevent it being adopted on a wide scale in the UK (RCEP, 2004). Conversely, willow has a fairly high water requirement, which can affect surrounding areas and habitats, such as wetlands or local streams (RCEP, 2004; DTI and DEFRA, 2007). To make the growth of energy crops economically viable, they currently require subsidies, and indicative figures for the average annual income that could be generated from medium yields of willow SRC and miscanthus are between £187-360 per ha (Boyle 2004, cited in RCEP, 2004), with the wide range possibly due to local socio-economic factors.

There have been mixed reactions towards the use of SRF, with RCEP (2004, p13) claiming that it "is not seen as a major source of biomass for fuel". It has not been practised to the same extent as other energy crops in the UK and a limited amount of research exists on the impacts related to its production, with no code of practice currently available (Hardcastle, 2006). However, Hardcastle (2006) claims that it has good potential for use as a biomass energy source in the UK and according to the Forestry Commission, SRF is "the option that is best suited to Scotland's growing conditions" (Forestry Commission, Undated, p2). SRF differs from other energy crops as harvesting takes place over longer time frames (5 to 15 years), resulting in slower returns on investment. Yields are also lower than many energy crops, with species such as Ash having an annual yield of 7.4 dry tonnes per ha (Hardcastle, 2006). Certain non-native species, such as *Eucalyptus*, also consume a high amount of water, placing pressure on water supplies in certain parts of the UK (Forestry Commission, 2006). Whereas SRC plantations are grown with the specific purpose as a biomass energy crop, however, SRF offers the possibility to be used in other markets such as a timber, if this were to be the most profitable end use (Forestry Commission, Undated). Moreover, SRF can produce a better quality product on more marginal agricultural land than SRC (Forestry Commission, Undated). Research for SRF is slowly being upscaled and in 2009 the UK Renewable Energy Strategy (HM Government, 2009b) announced a three-year research project, with total funding of £1.5 million to investigate the potential of SRF as a biomass energy source.

Online accessible DEFRA opportunity maps[6] are available, showing regional yields in the UK for miscanthus, SRC and existing energy crop locations, and they serve as a general guide in identifying the most suitable areas for growing energy crops (MacLeod *et al*., 2005). These types of maps are generally based on physical factors generating the highest yield (temperature, soil and water availability), and do not take into account some of the socio-economic factors that could affect the planting of energy crops (Lovett *et al*., 2009), nor do they identify surrounding energy markets (MacLeod *et al*., 2005). Haughton *et al.* (2009) use a more integrated approach to identify the land available in the UK for energy crop growth, using a combination of physical criteria (soil type, slope steepness, lakes, major rivers, urban areas and existing woodland), natural or cultural criteria (key habitats, nature reserves and heritage sites), and additional criteria such as sensitive landscapes or grassland, where the growth of biomass crops might be discouraged but not necessarily ruled out.

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[6] Found at: http://www.defra.gov.uk/foodfarm/growing/crops/industrial/energy/opportunities/index.htm.

They estimate that 3.1 million ha of land in England are suitable for growing miscanthus and willow, around three times as much as the target for bioenergy crops (which includes biofuels) identified in the UK Biomass Strategy - 1.1 mill ha by 2020 (DTI and DEFRA, 2007) - with considerable regional variation in the UK. This high estimate by no means suggests that all of it should be dedicated to energy crops, as it does not factor in potential land use conflicts over the use of the land for agricultural crops and, by extension, food security. It is, however, a way of indicating that there is sufficient land available in the UK and that government targets for energy crop growth are achievable.

Over the next century the growth patterns of energy crops may be affected by climatic changes across the UK and according to DEFRA (2007), under the UKCIP02 high-medium emissions scenario the overall area suitable for SRC growth will decrease across the UK, with the distribution of suitable areas moving to the West and North of the UK, shown in the figure below.

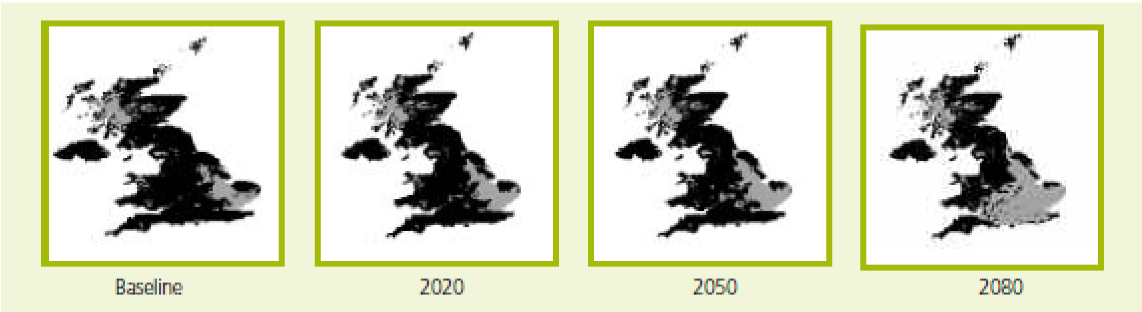



**Figure 11 Areas suitable for SRC growth in the UK (shaded in black) under the UKCIP02 high-medium emissions scenario for 2020, 2050 and 2080. Taken from DTI and DEFRA (2007).**

## 5.2 Impacts of growing energy crops

There are concerns about the impacts of increasing production of energy crops, such as those associated with land use change, since growth is predicted to occur on large areas of land and on short time-scales in order to generate sufficient feedstock (HM Government, 2009b). Energy crop plantations can have a range of environmental impacts, both positive and negative, as well as socio-economic impacts, some of which are discussed below.

- One ecosystem function that can be affected by the growth of energy crops, results from the impact on soil composition from land use change and any associated GHG emissions, especially when replacing previously undisturbed land such as permanent grassland (Environment Agency, 2009; DTI and DEFRA, 2007). The deeper roots of certain biomass crops can help bind the soil together and reduce soil erosion (DTI and DEFRA, 2007), whilst also building up the soil carbon content (Environment Agency, 2009). Replanting a plantation however requires deep tilling of the soils to remove the crop, which releases a substantial amount of carbon, thereby possible negating the accumulated soil carbon over the lifetime of the plantation (Environment Agency, 2009).

- In regard to biodiversity, impacts vary between the type of crop grown: native species such as willow, for example, tend to support higher levels of biodiversity through a larger number of invertebrates (Sage and Tucker, 1997) and greater species of birds (Anonymous, 1999), as compared to poplar (RCEP, 2004) and non-native species such as miscanthus (Haughton *et al.*, 2009). Currently, much more information is available on the biodiversity impacts of SRC willow than miscanthus but a greater number of studies with more robust methodologies and ecological indicators producing more comparable results are still being conducted in order to expand our knowledge base (Haughton *et al*., 2009). Despite this uneven information distribution, we do know that compared to arable crops, both SRC willow and miscanthus provide greater level of cover. This helps to attract small mammals, invertebrates, insects and birds, with the relatively long duration of plantations providing a well established environment for supporting different types of wildlife (Haughton *et al*., 2009).

To maximise biodiversity improvements, sensitive planning is crucial (RCEP, 2004). One criticism of the Energy Crops Scheme is that the biodiversity benefits of energy crops are not fully recognised, and the RCEP (2004) recommend that similar types of payments to those seen in the Countryside Stewardship Scheme for biodiversity enhancement should be awarded.

- A common argument against the use of energy crops is that they may compete with agricultural land, but within the grading system of agricultural land (1=best, 5=worst) (MAFF, 1988), perennial energy crops are discouraged from being grown on that of high quality, and instead encouraged on more marginal land (Campbell *et al*., 2008). This is demonstrated by over four fifths of Energy Crop Scheme (2001-2007) approvals being awarded to crops grown on grade 3 or 4 land (Nature England, 2008, cited in Haughton, 2008). The Teeside case study (Box 3), is one example of a large-scale biomass plant encouraging the use of marginal land for energy crops. Experimental sites are being used to measure whether crops planted on marginal land will generate sufficient yields (Sherrington *et al*., 2008) and the UK Biomass Strategy stresses the importance of crop breeding programmes to identify specific genotypes that can produce good yields on marginal land (DTI and DEFRA, 2007). There is a risk that energy crop plantations may extend to better quality land in the future, if their prices become more competitive with staple crops such as grain (DTI and DEFRA, 2007).

- The impacts of energy crops are more than just environmental; they also include a range of socio-economic impacts. These can include implications for tourist and farm income, landscape aesthetics, and cultural heritage - although the extent of these impacts depends on local characteristics and the type of land use being replaced (Haughton *et al*., 2009; Lovett *et al*., 2009). The degree of impact will vary across each location, and each will need to be individually assessed and monitored over the next decade. Guidelines for best practice to minimise these impacts have been released in the past by DEFRA (2007b; 2004) and Tubby and Armstrong (2002). The guidance note of the Forestry Commission (2001) also provides several recommendations on how to lower visual impacts of SRC plantations, for example by growing a selection of different aged crops near existing woodland, which can also help establish ecological corridors; planting shrubs alongside plantations; and steering clear of large geometric plantations on high ground. To better understand the impacts of energy crop expansion in the UK, further research such as the RELU-biomass project[7] is required.

## 5.3 Assistance for growing energy crops

Energy crops tend to be higher in cost than other biomass resources and a growing amount of support is being diverted to make them an economically viable alternative for farmers and help with the costs associated with their establishment, planting and harvesting (RCEP, 2004). Eventually these

[7] This provided an holistic assessment of the potential impacts of increasing rural land use under miscanthus and SRC willow. Details found at: www.relu-biomass.org.uk/index.php

costs are expected to fall due to economies of scale, improved efficiencies in harvesting and the collection and identification of strains with higher yields (RCEP, 2004; MacLeod *et al*., 2005).

The Energy Crops Scheme has been an important incentive in supporting the expansion of energy crops but it has been criticised for not being organised effectively. For example, establishment grants are awarded shortly after planting has taken place, after which there may be three or four years before farmers see their first source of income following the first harvest (Personal Communication, 2010b). This could be overcome if plants of different ages and species are planted, thereby generating an annual harvest (RCEP, 2004), but this would still take time to establish. Moreover, to be eligible for the energy crops scheme farmers must be able to demonstrate guaranteed demand through long-term contracts with biomass generators (Personal Communication, 2010b). This can be difficult to obtain due to the long time-frames involved in the application and preparation process in establishing the crop, and the ease for generators to currently obtain imported stocks and still benefit from the Renewables Obligation (RCEP, 2004). RCEP (2004) recommend that ROCs only be awarded to generators if they able to offer long-term contracts to growers. Other grants schemes include the Bio-energy Infrastructure Scheme, Energy Aid Payments and the Wood Energy Business Scheme, details of which are found in spreadsheet 3.

## 5.4 Conclusion

It is still early days and farmers remain hesitant to switch to growing energy crops on a large scale, especially without the assurance of long-term market security for crops produced on plantations lasting around 15-20 years (RCEP, 2004). With no flexibility to alternate crops on an annual basis based on changes in market price (as with agricultural crops), there needs to be a guarantee that a fair market price for energy crops will exist for the duration of the long-term cycle of the energy crop plantation, thereby increasing confidence among farmers. The rising number of biomass generators in development is starting to create a more secure market for these products, although there is a concern that they may have to continue competing with imported feedstock.

# 6 Other sources of biomass

## 6.1 Woodfuel

Woodfuel is an extremely important biomass feedstock, which can originate from various different sources such as existing woodland, sawmill co-products and arboricultural arisings. Estimates from the Forestry Commission (2003) stated that the UK had approximately 3.1 million odt per year in woodfuel resources, dropping to 1.3 million odt per year if competition for woody resources from other industries were considered (RCEP, 2004).

In 2007, the Forestry Commission conducted a Woodfuel Strategy for England, with the aim to increase annual woodfuel production by two million tonnes (Mt) (one million odt per year) by 2020 (equivalent to carbon savings of 0.4 Mt of carbon per year). This would be primarily from under-managed woodland, with the end use mainly directed at local heat generation, due to its fairly dispersed distribution. This would make up approximately two per cent of the renewable energy target by 2020 (HM Government, 2009b). In 2007, only two fifths of the annual increment in woodlands found in England was used as biomass feedstock. To achieve the above target of the Woodfuel Strategy, it is suggested that wood production needs to rise by 60 per cent (Forestry Commission, 2007). To accompany this projected increase in woodfuel, an improved skilled workforce, better infrastructure, enhanced supplier confidence and improved woodland accessibility is necessary (Forestry Commission, 2007). The map in figure 12 gives an idea of the level of managed and unmanaged woodland in England and shows that a large amount of undermanaged woodland exists scattered across the country.

There are a number of grants directed at woodfuel expansion, such as the Woodfuel East Strategic Investment Support Programme, the Better Woodland for Wales scheme and Rural Development Contracts (spreadsheet 1). Unfortunately, their use has been limited by woodland owners, as there is a general perception that felling trees may result in negative environmental impacts, and there are low levels of awareness of some of the positive impacts that can arise from ecologically sensitive woodland management; such as contribution to a cleaner energy sector, diversified woodland structure, higher levels of biodiversity of a variety of flora and fauna (Forestry Commission, 2007), preservation of historic and cultural value of woodlands, increased accessibility and even landscape improvements (DTI and DEFRA, 2007). Other reasons for relatively high levels of unmanaged woodland have simply been due to disinterest, poor knowledge of the grants available, resistance to changes to familiar landscapes, concerns about impacts on biodiversity, and a low level of technical knowledge, skills and specialised equipment (Forestry Commission, 2007). Profit-making may not necessarily always be the main incentive for forest owners, however, and the differing needs of woodland owners should be recognised.

The ability to identify and engage woodland owners is now vital, to enable them to access sufficient information to make the best informed choices (Forestry Commission, 2007). Training needs to be upscaled to enhance the current level of technical support and skills, for woodfuel supply to be optimised in an environmentally sensitive way (Forestry Commission, 2007). This is particularly important, as forest residues and deadwood provide a range of important environmental functions such as water and soil regulation, and any biomass removal must be carried out in a way that minimises any negative impacts towards these functions (DTI and DEFRA, 2007). Wherever possible the principles of Sustainable Forest Management should be adhered to (Forest Europe, 2009), as well as adoption of the UK Forestry Standard (which is compulsory with Forestry Commission grants) and the UK Woodland Assurance Standard (Forestry Commission, 2007). Moreover, woodfuel supply chains need to be further supported and wherever possible long-term supply contracts introduced to increase confidence among woodland owners (Forestry Commission, 2007).

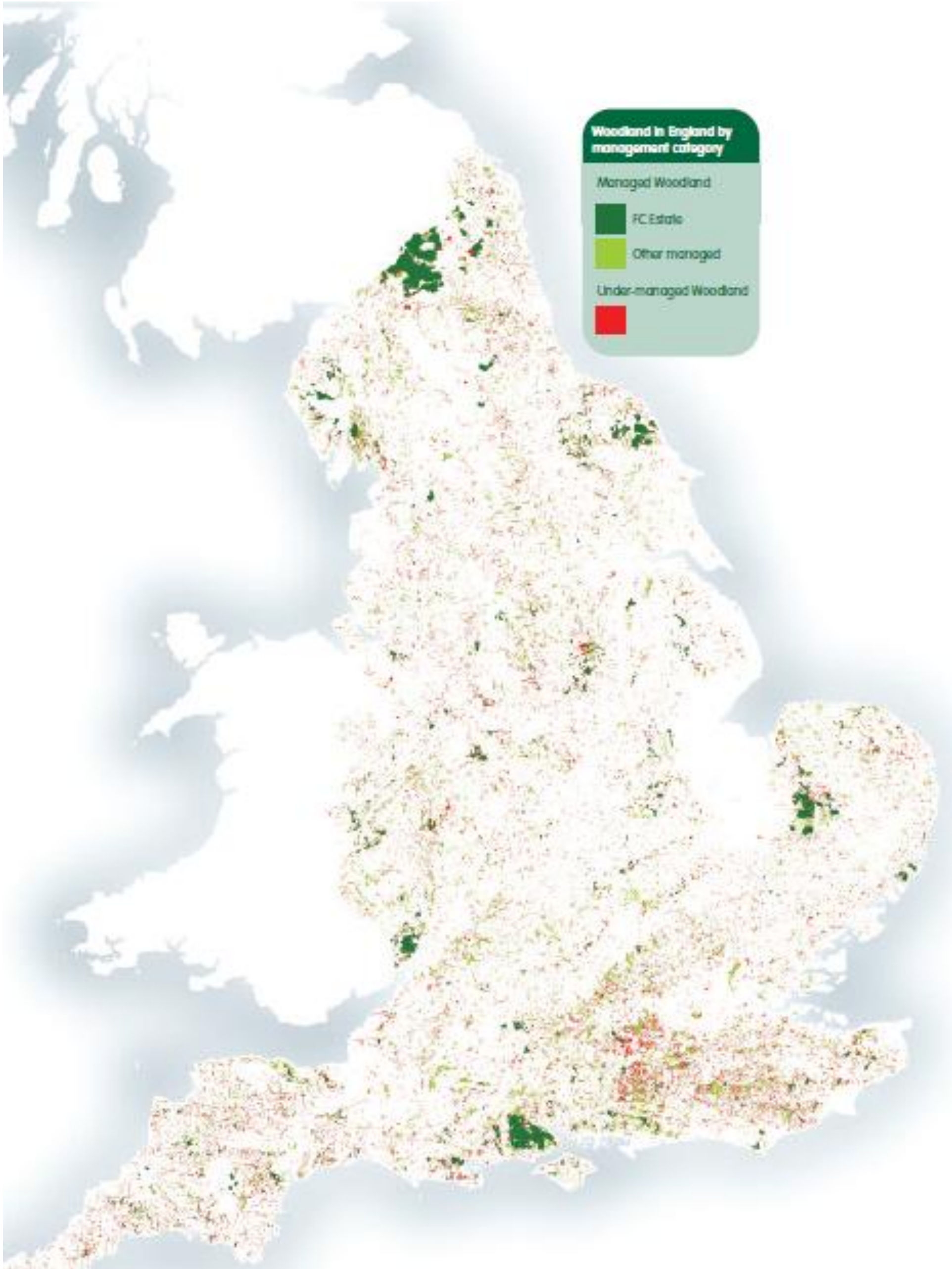



**Figure 12 Map showing the distribution of managed and under-managed woodland in England. Taken from Forestry Commission (2007)**

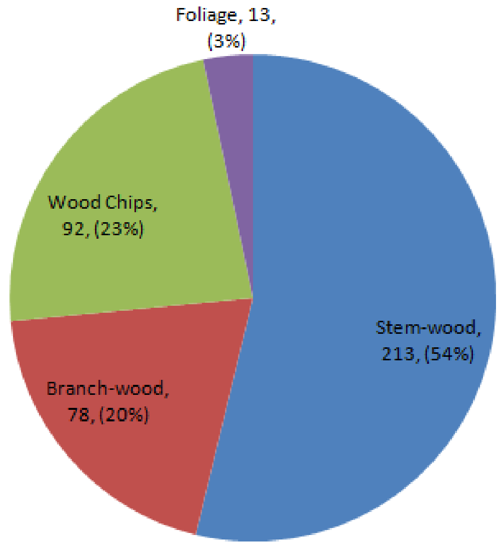



**Figure 13 Pie chart showing the estimated annual arboricultural arisings in England (thousands of tonnes at oven dried weight). Created by author, data taken from Forestry Commission (2007)**

A large amount of woodfuel can also be generated from arboricultural arisings, much of which would otherwise end up as waste wood. Figure 13 shows the estimated annual arboricultural arisings in England, which can be used directly or converted to more efficient wood chips or pellets (RCEP, 2004, Forestry Commission, 2007). According to the Forestry Commission (2007), municipal arisings could reach 492k odt per year if fully exploited and, due to the very dispersed nature, this waste is more suitable for small-scale district heat or CHP production (RCEP, 2004). To help increase its concentration municipal arisings could be mixed with other form of recovered waste wood (Forestry Commission, 2007). However, there are limited opportunities for storage or processing of municipal arisings at source, making it difficult to reach the low moisture content that some small-scale applications demand (RCEP, 2004).

## 6.2 Waste biomass

As seen earlier in figure 3, a considerable amount of biomass resources are made up of different forms of biomass waste. In 2005, six per cent of renewable electricity came from waste biomass and the UK government hope to increase this proportion further (DTI and DEFRA, 2007). Waste biomass is one of the most cost effective biomass feedstock options (DTI, 2007), due to the avoided landfill tax (Environment Agency, 2009; MacLeod *et al.*, 2005) and the extremely low or negligible marginal costs of redirecting it to an energy plant instead of landfill (RCEP, 2004). Nevertheless, despite its abundance, it is thought to be significantly under-utilised. Much of biomass waste is wet waste, such as animal manure, wet food waste and sewage sludge. Their high moisture content means they use different technologies than those discussed in this report, such as anaerobic digestion. Due to time constraints they are not discussed any further here, but nevertheless their importance as a substantial biomass resource is acknowledged. Dry waste such as arable crop residues, woody waste or different forms of industrial waste can be combusted, however at the moment, much of it is directed to landfill. In 2007, for example, an astonishing 80 per cent (6 million tonnes) of a total of 7.5 million tonnes of waste wood was sent to landfill (figure 14) (DEFRA, 2007c). There is therefore great potential to divert it for use as an energy source, leading to significant GHG savings (DEFRA, 2007a). In some instances, biomass energy plants can be located adjacent to an industrial operation such as a paper mill (as seen with the RWEnpower 50 MW plant in Fife, spreadsheet 1), in order to maximise the use of biomass residues.

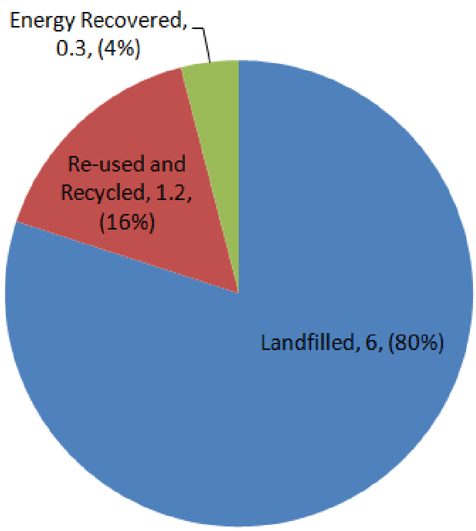
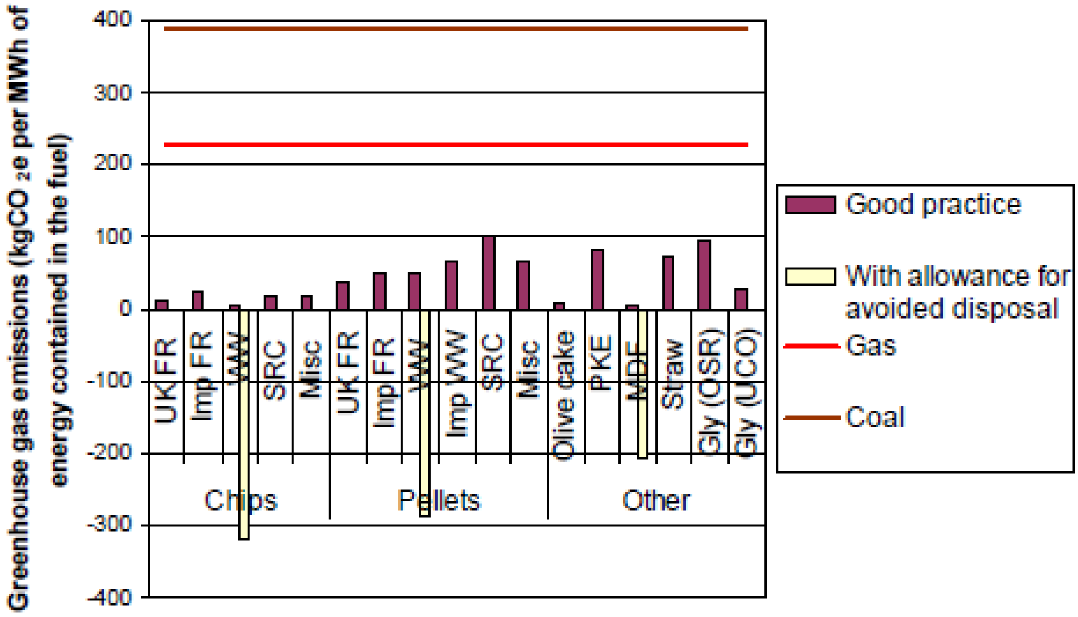



**Figure 14 Pie chart showing waste wood arising in the UK (million tonnes). Created by author, data taken from DEFRA (2007c).**

To promote the use of all forms of waste biomass, it should be collected separately wherever the facilities allow. Where this is not an option, the biomass energy content of mixed waste streams ought to be determined to allow its eligibility under the RO (DTI and DEFRA, 2007). One of the limitations of biomass waste for energy has been the negative public perceptions associated with its use, with a reluctance to have any energy waste plants located close to concentrated population areas because of health concerns (DTI, 2007). This can be partly overcome with sufficient information campaigns on the environmental benefits of biomass waste use.

# 7 Greenhouse gas emissions

Although it is widely acknowledged that the use of biomass can lead to savings in GHG emissions compared to coal and gas, emissions are released at various stages of the biomass energy supply chain, such as during the production, processing (for example, pelletisation) or delivery stages, as well as from land use change.




| | | | |
|---|---|---|---|
| UK FR | UK forestry residues | Imp FR | Imported forestry residues (from the Baltic) |
| SRC | Short rotation coppice | Misc | Miscanthus |
| WW | Waste wood | Imp WW | Imported waste wood (from the Baltic) |
| PKE | Palm kernel expeller | MDF | Medium density fibreboard |
| GLY | Glycerine from biodiesel production | (shr) | shredded |
| (OSR) | using oil seed rape | Gly | Glycerine from biodiesel production |
| | | (UCO) | using used cooking oil |

**Figure 15 Graph showing the variation in GHG emissions, released during the production, processing and delivery of various different types of biomass feedstock. Taken from Environment Agency (2009; PB Power, 2008)**

Life cycle emissions can vary depending on the quality and type of biomass feedstock, conversion efficiencies, transport distance, regulations and abatement technologies (Forestry Commission, 2007; DTI and DEFRA, 2007). As figure 15 identifies, there is a large difference in GHG emissions between different feedstocks and how they are processed, with up to a tenfold difference between emissions released from waste wood (10kg $CO_2$e per MWh) compared to pellets derived from SRC chips (100 kg$CO_2$e per MWh). Pelletisation requires additional energy but the advantages are increased homogeneity and density, and decreased moisture content (RCEP, 2004). This makes them easier to handle and store, with a higher overall energy potential (Environment Agency, 2009). The white lines reflect the avoided GHG emissions from the disposal of waste wood and medium density fibreboard to landfill. Since the GHG emissions from landfill disposal would otherwise have been substantial, providing an allowance for avoiding them results in negative GHG emissions. It should be considered, however, that not all waste biomass would necessarily have been directed to landfill; some may be recycled to generate useful products, such as particleboard (Environment Agency, 2009). Consequently, when analysing GHG savings for waste biomass, all different end uses should be taken into consideration because different assumptions can lead to different estimations of GHG emission savings.

The data in figure 15 are based on 'good practice' in biomass production. Figure 16, however, shows that large ranges of $CO_2$ emissions exist mostly due to variations in fuel production and, to a lesser extent, conversion efficiencies (Environment Agency, 2009). The lowest $CO_2$ emissions – and smallest range of emissions – are seen with SRC chips in domestic boilers. This is due to the considerably higher efficiency than that of dedicated biomass power plants or co-firing plants, and the lower level of fuel processing required compared to SRC pellets. The feedstocks used in biomass power plants show some of highest and largest ranges of $CO_2$ emissions. Interestingly, when bad practices and poor conversion efficiencies are used for straw production, the $CO_2$ emissions can even exceed those for gas. Despite the higher level of $CO_2$ savings that could be achieved from using clean wood waste compared to SRC chips if good practice is followed (as seen in figure 15), figure 16 shows that the worst practices and conversion efficiencies can reverse this trend. This graph thus emphasises that the level of emissions can vary greatly, and the Environmental Agency (2009, p14) suggests that one way to incentivise 'best practice' would be to introduce "a mechanism to reward feedstock which achieve higher greenhouse gas savings".

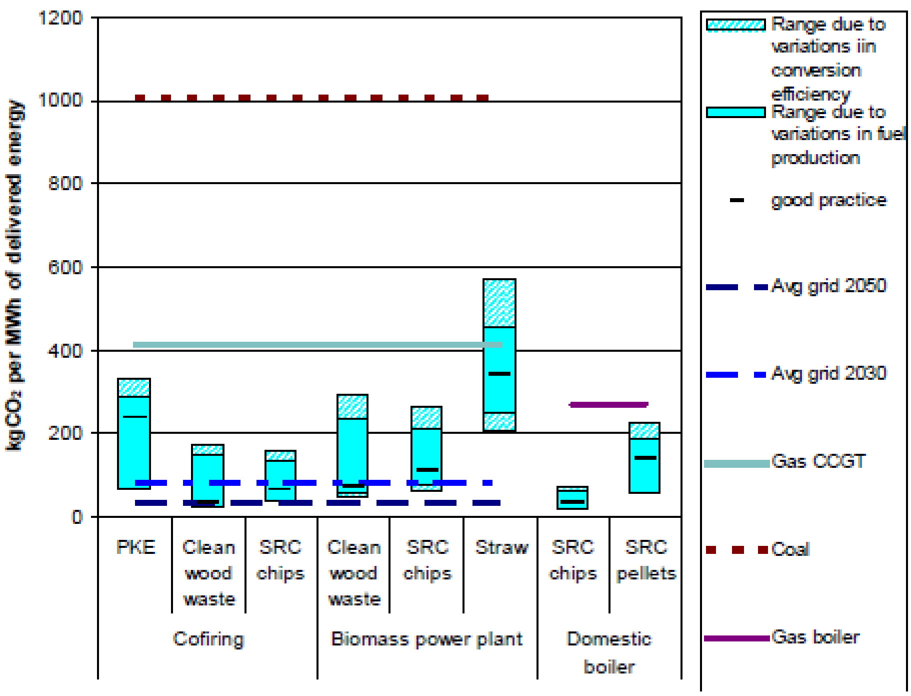



**Figure 16 Chart showing variations in life cycle $CO_2$ emissions for variations in fuel production and conversion efficiencies between different types of biomass and technologies. Taken from Environment Agency (2009)**

The Environmental Agency (2009) presents a hypothetical case study in the UK as a way of demonstrating $CO_2$ emissions associated with different scenarios of a 250 MW biomass power station, compared to a gas-fired power station (figure 17). Four different scenarios are considered, depending on whether North American or UK and European feedstock is used, in an electricity-only or CHP power plant. CHP shows the greatest reduction in emissions per MWh due to its higher conversion efficiencies, particularly when UK and European feedstock is used. For those plants that have already been built or designed for electricity extraction only, more locally sourced feedstock can help reduce emissions by around a third.

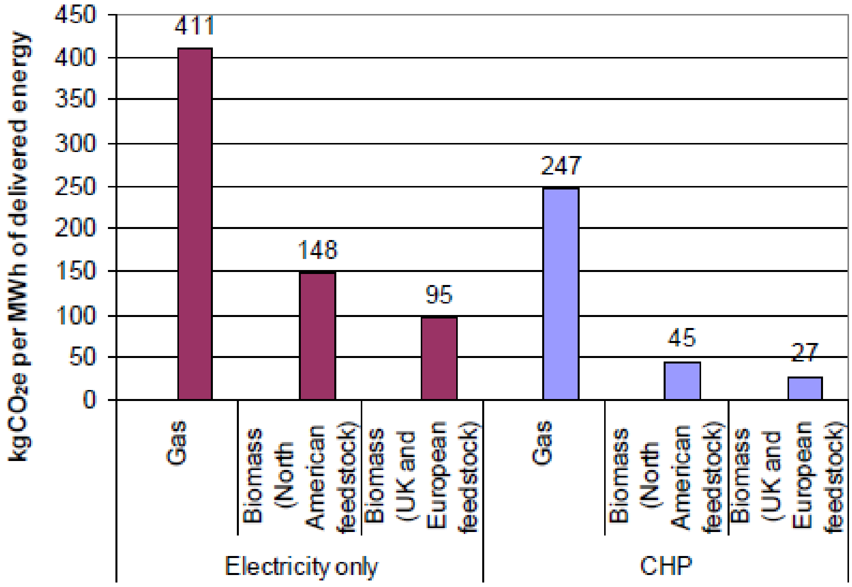



**Figure 17 Emission levels for four different scenarios of biomass energy compared to a gas-fired power station. Taken from Environment Agency (2009).**

## 7.1 Transport emissions

With a growing number of plants relying on imported feedstock, the emissions associated with transport over long distances has raised concerns as to whether these outweigh the emission savings benefits of using biomass for energy. According to the Environmental Agency (2009, p21), “transporting fuels over long distances and excessive use of nitrogen fertilisers can reduce the emissions savings made by the same fuel by between 15 and 50 per cent compared to best practice.” The table below provides a summary of the $CO_2$ equivalent emissions between the three main forms of biomass transportation – road, rail and ship.

**Table 5 Showing the estimated transport costs and $CO_2$ emissions between the three main modes of transport for different fuel stocks, taken from RCEP (2004)**

<table>
<tr><th>Mode of transport</th><th>Fuel type</th><th>Transport cost (£/odt/km)</th><th colspan="2">$CO_2$ equivalent emissions (kg/odt/km)</th></tr>
<tr><td rowspan="4">Road</td><td>SRC (chip)</td><td>0.077-0.086</td><td colspan="2" rowspan="4">0.18-0.27</td></tr>
<tr><td>Miscanthus (baled)</td><td>0.058-0.080</td></tr>
<tr><td>Forest materials (chip)</td><td>0.077-0.086</td></tr>
<tr><td>Straw (baled)</td><td>0.102-0.139</td></tr>
<tr><td rowspan="4">Rail</td><td>SRC (chip)</td><td>0.040</td><td colspan="2" rowspan="4">0.028-0.048</td></tr>
<tr><td>Miscanthus (baled)</td><td>0.028</td></tr>
<tr><td>Forest materials (chip)</td><td>0.036</td></tr>
<tr><td>Straw (baled)</td><td>0.04</td></tr>
<tr><td rowspan="4">Ship</td><td>SRC (chip)</td><td>0.010-0.014</td><td rowspan="4">Sea<br>0.012-0.024</td><td rowspan="4">Waterways<br>0.022-0.066</td></tr>
<tr><td>Miscanthus (baled)</td><td>0.008-0.0011</td></tr>
<tr><td>Forest materials (chip)</td><td>0.010-0.014</td></tr>
<tr><td>Straw (baled)</td><td>0.014-0.019</td></tr>
</table>

At a first glance, road appears to be the most expensive form of transport, with the highest $CO_2$ equivalent emissions, followed by rail and ship. However, the shipping emissions shown here do not take into account the additional road transportation required to deliver feedstock from the place of harvesting to the port, and onwards from the port to the biomass plant, although some plants, such as the one in Teeside (Box 3), are already conveniently located adjacent to a port. Moreover, since the total distance travelled by ship would be greater than either road or rail, the cumulative costs and $CO_2$ emissions would be significantly higher (RCEP, 2004).

On the other hand, according to a study carried out in Sweden, there were other factors that were more importance than transportation distance in terms of avoided $CO_2$ emissions, such as, "the type of fossil fuel replaced [...] together with the net amount of biomass recovered per hectare of forest land" (Eriksson, 2008, piv). In regard to the latter, the author demonstrated that more biomass could be extracted per hectare and at a lower cost through a 'bundle recovery system' than a chip or pellet system, with minimal differences in cost between national and international sources of biomass (Eriksson, 2008, p49).

# 8 Barriers to biomass energy development

As seen through this report so far, biomass energy is slowly expanding in the UK but there are various barriers that still need to be overcome. This next section discusses some of these and provides recommendations for their improvement wherever possible.

## 8.1 Biomass supply chain

One of the major barriers to biomass energy in the UK is the lack of coordination and communication within the biomass supply chain, which stitches together fuel growers with generators and end users. A common chicken and egg problem exists, whereby the demand cannot develop without the supply and the supply without the demand. The Biomass Task Force identifies the demand as the key ingredient in pushing through the supply (MacLeod *et al*., 2005), and MGT

Power further confirm this statement, using as an example the construction of their Tees Renewable Energy Plant (MGT, undated-b). To a certain extent, larger plants have attempted to overcome this problem by relying mainly on imported stocks in the short term, in order to ensure sufficient supplies of biomass feedstock, with a medium to long-term vision to replace a proportion of this with UK stocks once a steady market has developed (RCEP, 2004; MGT, 2009). Reliance on imported stocks is something that needs to be closely observed over the coming years, especially for many of the large-scale plants currently in development. As RCEP (2004, p55) state, over-reliance on imported stock "reduces the incentive to UK farmers and foresters to diversify into fuel production and has implications for security of fuel supply for the UK and for UK agriculture and forestry". For smaller biomass plants at the community and domestic level, the poor development of supply chains that would guarantee end users locally-available biomass feedstock of sufficient quality, has been a significant limiting factor to the uptake of biomass technologies (Forestry Commission, 2007; RCEP, 2004).

Assistance for developing the biomass supply chain is partly provided through the Biomass Infrastructure Scheme. Their primary aim is to help with the technical development of the supply chain, as well as to strengthen the links and market infrastructure between fuel growers, generators and end users, to further facilitate the movement of biomass and communication between stakeholders (RCEP, 2004). It is hoped that support from this scheme will continue; recommendations for other ways of strengthening the supply chain are shown in table 6.

**Table 6 Recommendations for improvements to the biomass supply chain. Table created by author. Content quoted from Macleod *et al*. (2005), OPSI (OPSI, 2009) and the Forestry Commission (2007)**

| | **Recommendations** |
|---|---|
| 1. | The development of producer groups or co-operatives |
| 2. | Rigorous quality standards and certification to ensure that feedstocks are of a sufficient quality |
| 3. | The continuation of various grants such as the Energy Crops Scheme |
| 4. | Improved research into new feedstock options |
| 5. | Ensure that growers are well rewarded to keep supply levels high, through guaranteed end markets via long-term contracts, and possibly the introduction of energy supply companies |
| 6. | Clear communication channels between all stakeholders to ensure that a continuous dialogue is developed to address any concerns or problems that may arise |

## 8.2 Public awareness

The transition to biomass energy relies largely on a sufficient amount of public awareness. So far in the UK this has been limited, and has yet to attract the same degree of attention as in other European countries, with limited publicity in the media compared to other renewables *(MacLeod et al*., 2005). A lack of information on biomass energy has lead to misconceptions about its use and uncertainty as to whether a guaranteed supply of feedstock, such as woodchips, are locally available (MacLeod *et al*., 2005; Forestry Commission, 2007).

The creation of the Biomass Energy Centre has been an important medium in helping increase the level of public awareness (RCEP, 2004). Moreover, previous examples have shown that introducing biomass technologies at the community level, such as in schools, can be very effective in triggering public interest and acceptance (MacLeod *et al*., 2005), as seen in Nottinghamshire County, where biomass heating systems were installed in three schools (RCEP, 2004). The importance of domestic and community-level renewable energy projects is emphasised by the Urban Forum, who recently published a report outlining the level of support that is needed to make renewable energy, such as biomass, a stronger presence in people's homes, communities and businesses (Hathway, 2010).

With a growing number of medium to large-scale biomass power plants now in development, sensitivity, transparency and communication with the public during the planning stages are key, as seen in the Ridham case study (Box 4). The public is then kept actively involved and any concerns are addressed from the outset (RCEP, 2004).

## 8.3 Grants

As seen in spreadsheet 3, many grants exist to support different elements of the biomass energy sector, some of which have been touched upon in this report. Nevertheless, large-scale uptake of biomass energy has been slow and there has been criticism that the large number of grants available are complex and confusing. This has made it particularly difficult for small to medium-sized businesses to access the grants, with large variations between different parts of the UK and within different sectors, and focus primarily targeted towards larger-scale electricity-driven projects, with limited support at the domestic scale (RCEP, 2004; Forestry Commission, 2007; MacLeod *et al*., 2005). Furthermore, there has been an element of uncertainty in initiatives, with a large number of grants introduced, replaced or withdrawn over the past decade (MacLeod *et al*., 2005). Grants are also usually introduced on a short-term basis and come from a wide variety of different sources, therefore lacking consistency (Forestry Commission, 2007). A review of all of these grants is now essential, and wherever possible they need to be simplified and harmonised, to make them more accessible to a wider number of users (MacLeod *et al*., 2005).

# 9 Lessons for developing countries

Interest in the biomass energy sector is also growing in other parts of the globe. Being able to draw on experiences from our own development path here in the UK can provide valuable lessons, especially for developing countries that already rely largely on biomass as their energy source, albeit through a more informal sector. Some of those lessons that could be applied elsewhere are presented in this section:

1. Biomass energy not only contributes to national energy security but is also employment intense in comparison with renewable alternatives. It provides a wide variety of employment opportunities at all levels of the biomass supply chain, particularly for rural communities who might otherwise have limited employment prospects. Greater employment opportunities can contribute to higher levels of sustainable development and thus biomass energy should be considered an important component in poverty reduction strategy papers (PRSPs).

2. The mismatch between supply and demand seen in the UK may also arise in developing countries, especially around urban centres. However the main difference between countries such as the UK and developing countries is that biomass (mainly woodfuel) already makes up a much more significant proportion of the energy supply in many developing countries. At the same time, it is often founded on far less sustainable natural resource management and much less efficient conversion technologies. Nevertheless, in many parts of the developing world, good functional supply chains for biomass energy already exist. Rather than being shut down, these supply chains need to be made more sustainable and efficient through clearer incentives to restore and manage the resource, improved market links between fuel growers, generators and end users, and more substantial investment in efficient biomass conversion and use technologies. Most of the recommendations for improvements to the supply chain in table 6 are also applicable to developing countries. This will enable developing countries to expand, and incorporate a wider range of biomass sources, fuel growers and suppliers. Further, more efficient and less polluting technologies should be introduced, in addition to the encouragement of better quality biomass supplies. This includes

better drying and storage, better conversion using modern charcoal kilns or through bundling or pelleting, and more diverse and efficient end usage, such as fuel efficient stoves or new electricity generating plants, where it is cost effective to do so.

3. As has been the case in the UK over the last few years, developing countries should consider biomass energy as a major part of their renewable energy strategy, especially since it already forms a large proportion of the energy supply in many developing countries. To help guide this, the development of a biomass energy strategy, setting out key government policies and methods to achieve key targets and to build capacity in the sector is advised. A coherent biomass energy strategy can help minimise the level of disjointed and overlapping biomass energy policies, which has been one of the criticisms in the UK. Detailed, long-term planning is a key ingredient for any national biomass strategy, as identified by DTI and DEFRA (2007). There is also a substantial challenge to be overcome in some developing countries, where rates of time preference are high (Poulos and Whittington, 2000); or where there is government instability or vested interest in existing energy supply options.

4. As in the UK, biomass feedstock will come from a wide range of sources, including natural forest, if these can be shown to be sustainably managed. Local niches of different sources of biomass will need to be identified. When introducing energy crops, not all those that are suitable for biomass energy production in the UK will necessarily be so in other countries, due to differences in climatic, socio-economic and cultural conditions. Extensive research can help identify the crops best suited to a specific soil type or climate, to ensure the best yields and thus maximum returns. Wherever possible, opportunity maps (incorporating yield, suitability, and socio-economic factors specific to the region) should be made widely available, to identify the best areas for growing different biomass energy crops.

5. Different scales of biomass energy technology exist in the UK, from domestic boilers to 300MW power plants in development, and developing countries are encouraged to explore and adopt a similarly wide portfolio of technology options. As the biomass energy sector continues to expand in any country, there will also be a need to build up the number of trained and skilled professionals for all different scales of biomass technology, through dedicated government-supported technical training programmes that meet national standards, to install, operate and maintain such systems (MacLeod *et al*., 2005; Forestry Commission, 2007; DTI and DEFRA, 2007).

6. The Forestry Commission (2007) believes that the future of the biomass sector should be dictated by a bottom-up approach, by ensuring that farmers, woodland owners, the domestic sector and communities are kept well informed of the benefits of using biomass energy and provided with the right level of support, resources and information. It is recommended that forestry departments in developing countries similarly invest in building up awareness levels regarding the potential of biomass energy for the future, at both general and technical levels (Forestry Commission, 2007). Intensive government education programmes can help to increase understanding in all stakeholders, and the general public, about the biomass energy supply chain. An information hub, such as that provided by the Biomass Energy Centre, could be an important awareness-raising platform, providing a deeper understanding of the benefits of using biomass energy and increasing confidence amongst all stakeholders. Nonetheless, in order for biomass energy to expand beyond localised supply chains, this will need to be met to a certain extent by a top-down approach, with adequate government structures in place to introduce the right level of policies, government targets and strategies.

7. With transport costs being a significant component of biomass energy costs, the importance of delivery at the regional and sub-regional level needs to be recognised, as seen with the Regional Development Agencies (RDAs) in the UK. This is especially the case for domestic and community-scale projects, as this provides much more targeted support, sensitive to local needs. RDAs will have an important role in identifying local biomass sources and matching these up with energy demands, as not all sources of biomass will necessarily be evenly distributed throughout the country and it is highly likely that biomass feedstock may change over time.

8. As stated by the (Forestry Commission, 2007, p26), “a national core of research and development, advice and advocacy” is important in any biomass strategy. To avoid duplicated efforts, developing countries should engage internationally, in order to participate in information exchange and make use of the research already carried out and the lessons learned in other parts of the world. Forming part of the Global Bioenergy Partnership and the International Energy Agency Bioenergy Implementing Agreement are ways this can be achieved (DTI and DEFRA, 2007).

9. One of the main concerns about bioenergy in developing countries is the level of sustainability that can be achieved. The UK has made considerable strides towards locally controlled forestry in recent years, based on the understanding that the multiple local products and services provided by forests create a powerful local incentive to manage the forest sustainably, if authority over forests is devolved to community level. Where close monitoring of social, economic and environmental impacts is handled at local level, forestry departments can take on a role that is orientated more towards the development and monitoring of sustainability criteria and guidance on best practice (DTI and DEFRA, 2007).

10. Lastly, the level of GHG savings from using biomass energy are substantial but can vary widely between ‘good’ and ‘bad’ operations and practice (Environment Agency, 2009). Biomass energy can both help to mitigate climate change through emissions savings, and help local people adapt to climate change by providing more diverse and robust income generating opportunities. It should therefore form a key component of National Adaptation Programmes of Action (NAPAs) or strategies to Reduce Emissions from Deforestation and Forest Degradation (REDD). In some instances, biomass energy can be perceived negatively in developing countries, due to unplanned and uncontrolled biomass use. With good incentives for sustainable biomass production and use, and enforced standards and investment in modern conversion technologies, however, emission savings and adaptation opportunities can be significant at the national level. All stakeholders involved in the biomass supply chain need to be provided with sufficient information, guidance notes and support on how to achieve ‘best practice’, with the right incentives in place for doing so.

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# Appendix 1

**Calculation used to estimate the number of people employed in the woodfuel sector per 100 GWh**

In the Digest of United Kingdom Energy Statistics 2008 (DECC, 2008), figure 7.1 shows that the total renewable energy used in 2007 was equal to 5.17 million tonnes of oil equivalent. Using the conversion found in section 1.26 of 1 tonne of oil equivalent = 11,630 Kilowatt hours (kWh):

- 5,170,000 x 11,630 = 60,127,100,000 kWh (60,127.1 GWh)

In the 2007 Woodfuel Strategy for England (Forestry Commission, 2007), wood contributes 10 per cent of renewable energy.

- 10% of 60,127.1 = 6,012.71 GWh

According to the Biomass Energy Centre (Undated), approximately 5,524 people are employed in both directly and indirectly in the woodfuel industry.

- If 5,524 people are employed for every 6,012.71 GWh, then for 1 GWh, 0.918 (5,524/6,012.71) people are employed.

In other words, for every 100 GWh, 91.8 people are employed in the woodfuel industry alone. If it is considered that the biomass energy sector encompasses much more than just woodfuel, this figure is significantly higher for the whole of the biomass energy sector.